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THE NEW DIGITAL COMPUTER OF THE POLYTECHNICAL UNIVERSITY BUDAPEST

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(Received May 11, 1959)

I. Historical background

The idea of devising a digital computer first came to head in 1955. It was two years earlier in 1953 that instruction of switching technics was taken up in the curriculum of the Chair of Wired Telecommunication of the Polytechnical University, Budapest, and soon the need was greatly felt for having some sort of an equipment on hand, suitable for the practical demonstration of switching operations. Consequently, the principles to be embodied by this new design had to be mainly *didactic* ones. In addition it was thought appropriate that the new computer should be so designed as to allow other chairs of the University to refer any particular mathematical problems of their own sphere to the computer for handling.

Before taking up actual design work a number of points had to be made clear. The Hungarian Academy of Sciences offered its help to the promoters. For both capacity and dimensions the computer had to be designed with due regard to the limitations set by the amount at disposal. Moreover, the promoters of the digital computer had also to bear in mind that it was the Academy itself that had already commissioned its own Institute of Cybernetic Research to construct a computer. Substantial assistance had been extended to this Institute, mainly in the form of informative Soviet matter. Here the guiding principle was that the computer should be large enough to satisfy the country's need for calculations, mainly in the sphere of economics, for many years to come. With these considerations in mind the decision was thought appropriate, that in case of the University's computer, the components produced in Hungary in bulk should be given preference. At that time manufacture of electronic apparatus and assemblies had not yet been taken up by the Hungarian industry, so that even for the equipment of the Institute of Cybernetic Research the majority of assemblies and components had to be brought from the Soviet. On the other hand, production of electromagnetic relays for telephone exchange equipment was at that time already established since several decades. Undoubtedly, computers may be built up of any two-valued elements such as relays are. However, by resorting to this expedient, the designers of the computer had from the very outset reconcile themselves to a lower speed of operation inherent to relay type equipment, inasmuch as a computer incorporating electromagnetic relays only would work much slower than one composed of electronic units. Still when it was remembered that the computer would mainly serve purposes of instruction, and would be called upon for no special works, then in the opinion of the designers lower speed meant no particular disadvantage.

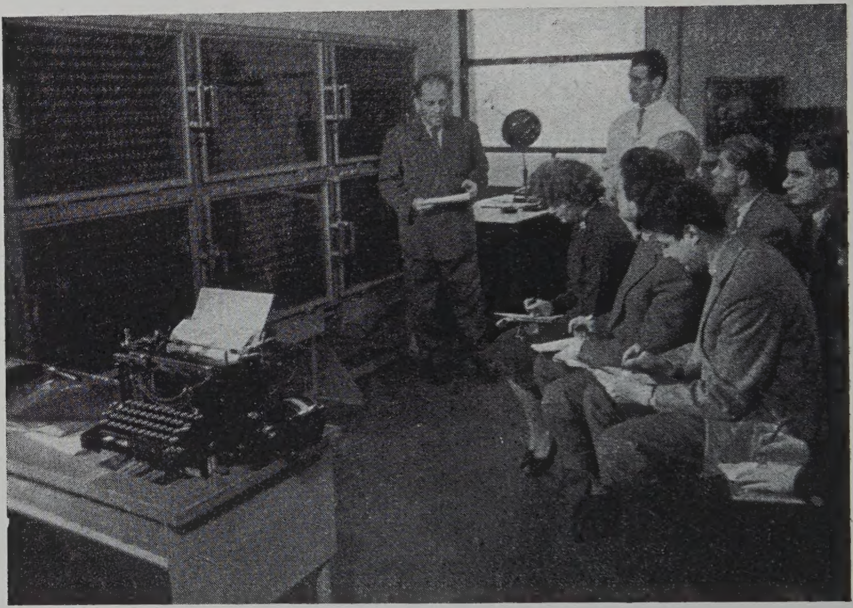

Fig. 1. Overall view of the computer

The use of relays of home manufacture, as a matter of course, entailed that the circuit had also to be developed at home. Although foreign circuit diagrams were also accessible, still their use was prohibited by the fact that these circuits were based on relays of altogether different operational characteristics. Also the designers were fully aware of the fact that circuit diagrams by themselves meant little or nothing in the line of assistance without their associated specifications. As for relays of home manufacture, since each type of relay had its own specific time of operation assigned to it, the rather convenient decision was taken to adopt the cheapest type, *i. e.* Type "R", of relays for the circuits of the digital computer.

Circuit design work was entrusted to a single person, who did the work in his spare time. Consequently, this part of the work could not be completed

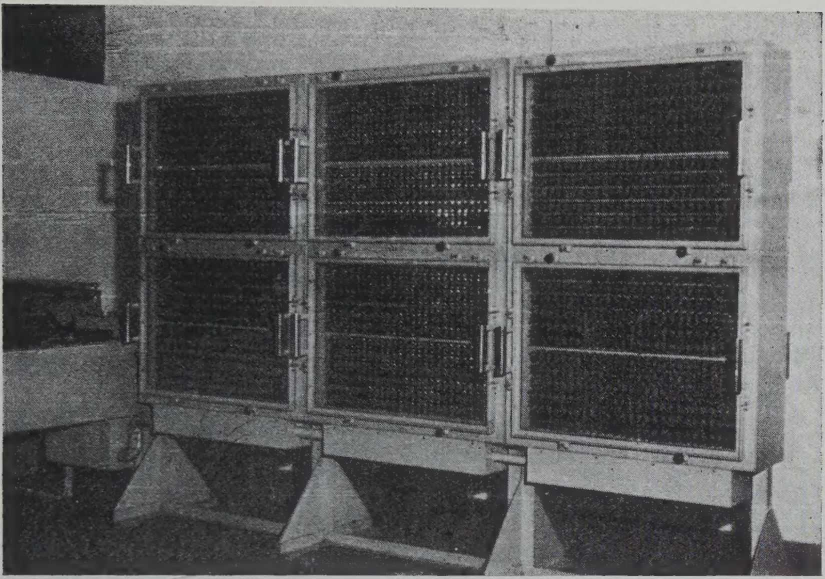

Fig. 2. The three relay cabinets

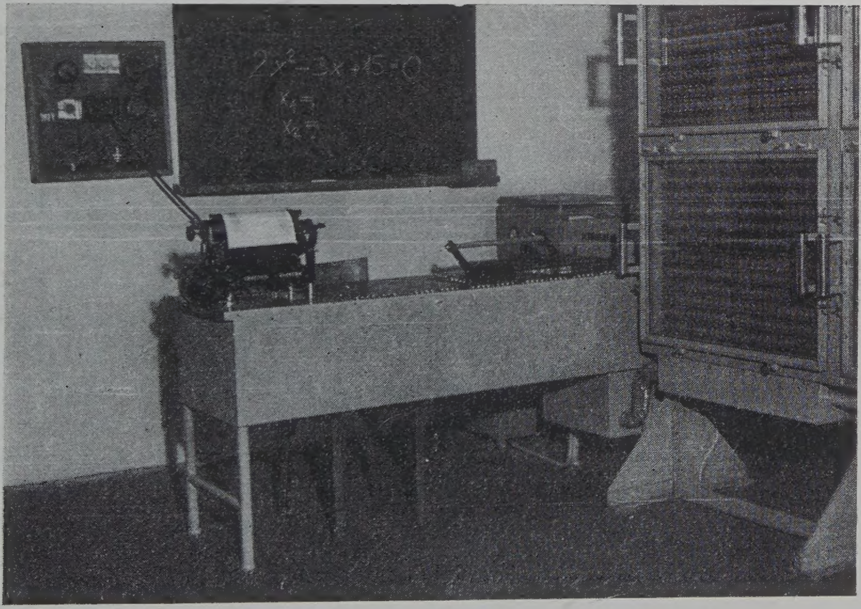

Fig. 3. Control desk of the computer

earlier than the spring of 1957. Assembly, cabling, and soldering were finished in the beginning of 1958, while electrical tests required a subsequent period of about a year. These comparatively long delays in the execution of the project were due mainly to the circumstance that only single persons who were actually working on the computer, and even these only in their spare time.

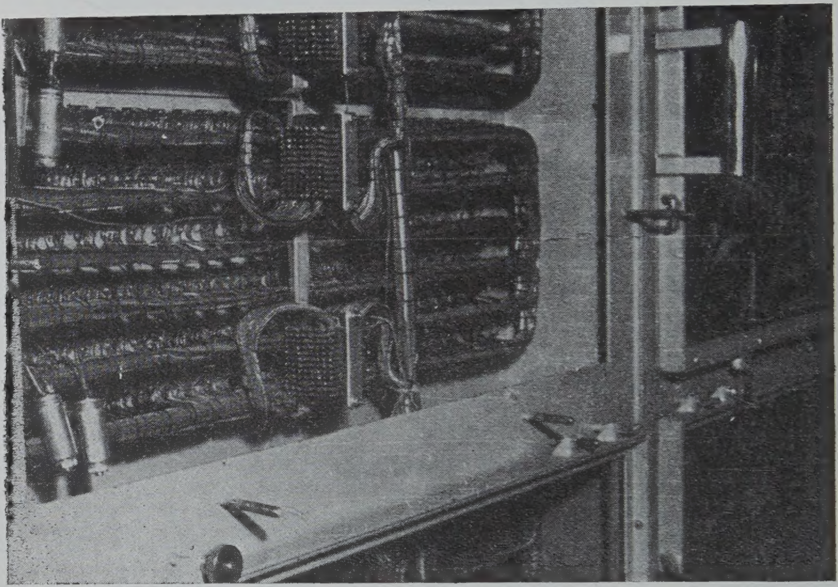

Fig. 4. Details of cabling

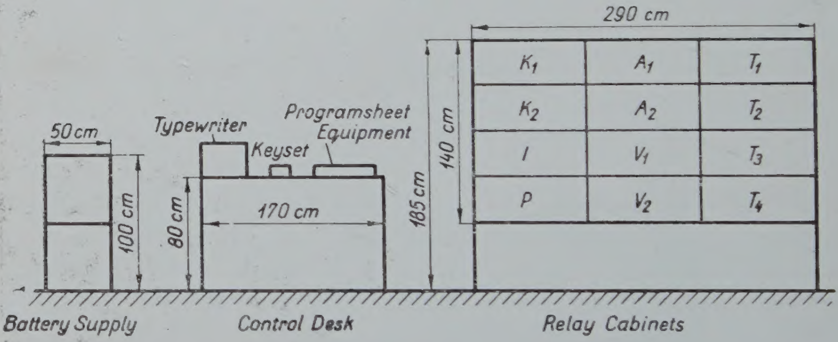

Fig. 5. Layout diagram of the equipment

Nevertheless, by the end of 1958 the computer could be completed, and in the current, 1959, year it was already used for demonstration purposes, moreover a number of calculating problems were already referred to it.

Since this was the first electrical computer of the University, it was given the code designation MESZ I. An overall view of the computer may be seen on the attached photograph Fig. 1. Other details are displayed in Figs. 2, 3, and 4, while Fig. 5 shows the schematic layout diagram of the computer with the main dimensions in the drawing.

II. Principal features of the equipment

In principle, Equipment MESZ I is *a programme controlled automatic digital computer built up of electromagnetic relays and operating on the binary system.* After the basic data have been introduced the equipment performs all operations in a wholly automatic manner without any external aid, and causes the results to be typed out by a conventional office typewriter fitted with actuating magnets. In principle, MESZ I is capable of performing any operation otherwise assigned to large electronic computers. However, owing to the restricted capacity of its memory units, for practical purposes an upperlimit had to be set to the volume of tasks which could be entrusted to the computer.

The complete equipment is assembled of three parts, *viz.*:

a) The control desk.

b) The calculator unit, composed of three cabinets fitted with relays.

c) The rectifier unit for power supply.

a) *The control desk*

The control desk accommodates the *programme reading device.* This device is substantially a field of contacts, on which certain groups of combinations of contacts can be earthed according to a pre-arranged pattern of perforations punched in a chart, made of insulating material. To each of the calculations individual perforated charts have been assigned with the *instructions* the equipment has to execute in order to solve a specific problem. Thus *e.g.* a mixed quadratic equation has such a chart associated with it, which, when inserted into the contact field pre-determines a set of operations the computer will actually *have to perform in a legitimate sequence.* Then at the end of this set of operations the two radices of the equation will be obtained as results, and typed out on the typewriter.

The basic data are fed into the computer by means of a set of keys. In addition to the keys associated with the ten digits of the decimal system, each key has been provided to indicate the negative sign, the decimal point, and the end of the digit.

Mounted on the control desk there is a conventional typewriter as used in offices. This typewriter records both the data introduced into the computer and the results obtained from the process of calculation, on a blank sheet of paper. Actuating magnets have been fitted under the keys required for the communication of information and results. The magnets themselves are actuated by the calculator itself in a pre-determined sequence.

b) *The calculator*

This unit incorporates close to *2000 relays* distributed over three cabinets. All relays are of *uniform design, i. e.* type "R" relays as manufactured by the Beloiannis Telecommunication Factory are used throughout. As for contact combinations and windings the close to 2000 relays include ten varieties only. The relays are mounted on twelve panels of uniform design. This number of panels is given by the pre-determined functions assigned to each individual panel.

c) *Mains rectifier unit*

The *mains rectifier unit supplies* the d. c. power required for the operation of the equipment, *i. e.* 60 volts, the power consumption on the d. c. side being 600 to 800 watts. For signalling purposes conventional switchboard lamps as known in telephone switchboards are used. These too are lighted with 60 volts d. c.

*

Each type of computer has a characteristic system of commands of its own allotted to it. Computer MESZ I is a *single-address equipment, i. e. a single command indicates the address of a single memory unit only.* Operations with two or more digits demand two or more commands, as the case may be. As regards design a single-address equipment is by far simpler than any of the frequently occurring double-address computers.

A single command having a row of twelve contact points associated with it on the programme chart, containing *two informations, viz.*:

1. *the type of operation to be performed*, and
2. *the memory unit in which the digit allotted to the operation is stored.*

These two data are recorded on the programme chart in the form of a binary code. Since the elements are of the two-valued type, out of the twelve points of a row with combinations of five

$$2^5 = 32$$

different operations may be performed, while with the combinations of seven

$$2^7 = 128$$

memory units may be marked out.

The maximum number of commands that may be registered on a programme chart is 45. When for the solution of a specific problem, commands in excess of this number are required, then depending on the actual number of commands, two or even more programme charts will have to be drawn up. As the computer is capable of storing all data in a manner independent of the programme charts, the charts may be exchanged while calculations are in progress.

Equipment MESZ I operates *on the binary system.* The basic data are introduced into the computer *on the decimal system*, and then translated automatically into a binary code. Re-conversion of the binary results to the decimal system automatically takes place in the same way. The results are then typed out in the decimal system.

As regards the number of memory units, the equipment in its actual design is still rather modest. Since owing to the limitations set to the dimensions the designers had from the very outset to waive the idea of using electromagnetic and electronic components in conjunction, relays having been employed also for the storage of information. One of the three cabinets of the computer was earmarked in its entirety for information storage, so that there are twelve memory units for digit storage, while a definite number of fixed memory units were assigned to storing certain numbers of particular importance, a few frequently recurring fractions, furthermore the values of π and e, and of certain logarithms. All these are, of course, stored in the binary system.

Corresponding to decimal numbers of eight digits the computer operates with binaries of 27 digits. In the memory units the digits are represented by *floating binary points*, the relays determining the order of magnitude giving the first "unit" of the number expressed in the form of different powers of two.

On assembling and cabling the panels the conventional methods, as used for the bays of telephone exchange equipment, were applied throughout. Between both the panels and the cabinets terminal strips were inserted, mainly to facilitate cabling, soldering, and failure tracing.

In its present design the computer contains parts and components representing an overall value of roughly one hundred thousand florins. *Labour* invested in the construction of the equipment expressed in the number of hours spent, adds up to the following figures :

Development	1500 hours
Engineering and draughting	1200 ,,
Installation, cabling, soldering	1500 ,,
Electrical testing	1400 ,,
Sundry work in shops	400 ,,
Grand total of labour	6000 hours

III. General principles of operation

A description of the method of operation of the computer is given here on hand of the block schematic in Fig. 6.

The three assemblies accommodated on the control desk have been given designations as distinct from those of the panels of the relay cabinets. The three assemblies are as follows :

1. the "carry-in" keyboard,
2. the typewriter, and
3. the programme chart assembly.

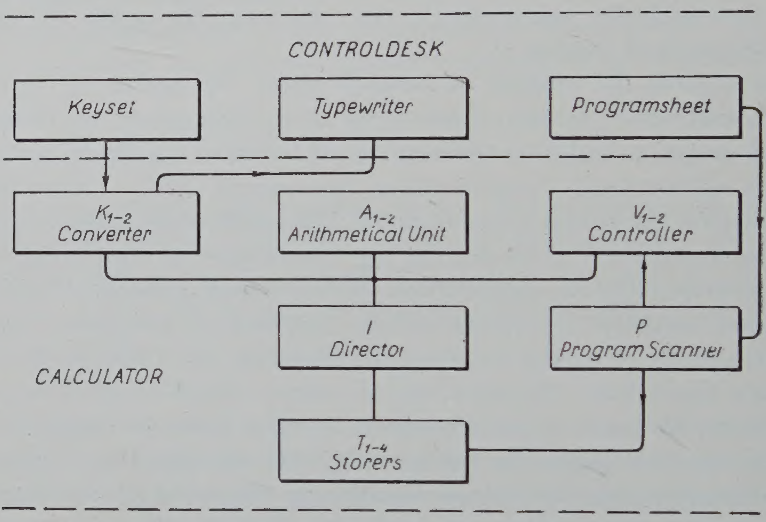

Fig. 6. Block schematic of the equipment

The twelve panels in the three relay cabinets have been designated with a capital letter each, *i. e.* the abbreviated symbolism expressing their respective functions :

K_{1-2}	Converter (translator) units
A_{1-2}	Arithmetic units
V_{1-2}	Control units
I	Director unit
P	Programme reader unit
T_{1-4}	Memory (storage) units

The constants of any problem are introduced into the equipment by means of a set of keys, and are then received in the converter unit. The end of the digits of a number is indicated by momentarily depressing key "Carry-in".

In response to the depression of this key circuit K_{1-2} translates the decimal number fed into the equipment into a number of the binary system, and advances this binary number over I to one of the memory units.

For conversion the known *method of halving-doubling* has been adopted. Panel K_1 is equipped with two halving, panel K_2 with two doubling circuits. The first halving circuit of K_1 receives the integers, the first doubling circuit of K_2 the decimal fractions. At signal "Carry-in" the halving circuits begin to halve, while the doubling circuits begin to double, among themselves. At halving odd numbers the residual units are passed on by K_1 to the register of circuit V_1, in the binary code. Similarly at doubling performed by K_2 the resultant integer "units" represent the values of the decimals in a binary code. Halving and doubling continue as long as the number to be converted has been exhausted, *i. e.* when K_1 and K_2 become vacated, or else the operation is stopped automatically when 27 doublings have been completed, this being the capacity of the memory units. (On the halving side a number of eight decimal digits will become exhausted anyway when 27 halvings have taken place.) The units produced by K_2 are advanced to the register of V_2.

In Appendix 5 the block schematic of conversion is shown, and the operation is illustrated by numerical examples.

The number thus converted into a binary expression now advances to the memory unit over units A_{1-2}, where when necessary it is rounded off before being stored. As a matter of fact the majority of numbers having a portion of decimal fractions may have 27 binary digits after translation, and, consequently, when such numbers have a portion of integers, then in the binary code there may be more than 27 digits, whereas the memory units were designed for a storage capacity of only 27 digits. Rounding off is performed in such a way that unit A adds unity to the value of position 28. This addition of unity will be ineffective whenever there is zero in the 28th position. On the other hand, unity is added to the number of 27 binary digits whenever there is unity in the 28th position. The binary number thus rounded off is then transmitted over the I director to the memory unit.

In the memory unit the binary number is stored in two parts. As a first stage the memory unit will store the possible number in the binary code of 27 digits, and then the memory unit will be informed by I of the order of magnitude of the number, *i.e.* the value of the first "unit" expressed as a power of two. Each memory unit is equipped with six elements for storing the order of magnitude (*i. e.* in principle the order of magnitude of any number in the binary code may actuate $2^6 = 64$ position values, however, actually only 54 values).

The translator (converter) then advances the digits simultaneously with the "carry-in" to the typewriter in order to fix on paper the starting data, *i. e.* the constants.

The final results of calculation, or any intermediate information, may then be "carried out" on the equipment. Since any number to be carried out on the computer is expressed in a binary code, the results will first have to be converted into the decimal system. This conversion takes place in the same translating circuits as have taken part in the conversion to the binary code.

Panel P is essentially an electrical sequence switch, activating the instructions *stored simultaneously in the programme chart* by discrete steps. After the starting data are introduced into the equipment, key "Start of calculation" has to be operated for a moment. On depressing this key circuit P carries out the first instruction of the programme chart. As has already been explained, this programme chart contains two informations, *viz.* the type of operation the computer has to perform, and, secondly, the storing place of the digit to be used for the operation. The instruction for operation is forwarded to control circuit V, which in turn *signals to all other circuits* the action they have to take in order to perform the operation. The programme chart further specifies the memory unit to be connected for the purpose of the operation to be performed.

Panel I constitutes a link between the memory units and the acting circuits K_{1-2}, A_{1-2}, and V_{1-2}. While the digits are stored with floating binary points in the memory units, the binary points are allotted a fixed point in the three acting circuits. The director is set by the order of magnitude. This director is essentially a switch having 27 branches and 54 positions built up of relays, and controlled on the binary system. The number stored in the memory unit and formed of a maximum of 27 digits passes over this director to the acting circuits, where it occupies a position corresponding to its real value on both sides of the binary point. Circuit I is a two-way circuit whose function is to take care of the transmission of the digits to the memory units in a correct manner.

The arithmetical unit of fixed binary points has a specific importance from *didactic* considerations. During tuition the operation of the calculator may be slowed down by means of a set of special keys to any desired speed, so that *partial results may at any time be visualized*, and also the momentary condition of control observed.

The function of control circuit V is, after collecting the operation instructions, to set all circuits in a condition suitable for the performance of the operation indicated. The functions of circuit V are decisively determined by the circumstance that the equipment is of the *singleaddress* type.

Arithmetical unit A is by itself capable of performing *addition only*. Substraction is in principle a *complementary addition*, and for operations including a set of additions, such as multiplication, division, extraction of roots, circuit V assumes the functions also of the *sequence switch*. Thus *e. g.* prior to multiplication the factor is passed on to circuit V, and in turn during multiplication the circuit advances the multiplicand as many times from the memory unit in the direction of A as there are "units" in the factor. Naturally, the circuit will in every case have in mind the order of magnitude of the multiplicand, and that of the unit actually multiplying. At multiplication it is circuit V which actually takes care of the addition of the different orders of magnitude, and at division of the subtraction of the orders of magnitude of the dividend and divisor. This will then determine the binary position value of the quotient. Extraction of roots is essentially a division, and only the value of the divisor changes, dependent on the value of the root already determined.

To sum up, the function of unit V is to cause the four rules of arithmetic to be performed in accordance with the instructions received. When any one instruction has been carried out, then V passes a signal on to P, in response to which P activates the set of instructions next in order of sequence on the programme chart. Consequently, instructions will issue to V to perform another set of operations. This cycle will then be repeated until all instructions on the programme chart are exhausted.

The result or results are in like manner "carried out" on the computer as the execution of a command. Unit V receives a signal indicating the memory unit from which the number stored there should be "carried out" to the translator. The number may in certain cases be carried out directly from A, or V itself as the case may be. Now K translates the binary codes into decimal numbers in a way that integers are doubled and fractions halved.

In addition to adding circuit A may perform comparisons, too. The circuit is capable of ascertaining which of two numbers is the larger, either in absolute values, or by virtue of their respective signs. While calculation is progressing, the circuit will be able to change its operation so as to comply with the conditions of such a comparison : the circuit may leap to any one row of the programme charts, both forwards and backwards, it may skip certain operations which as the result of comparison appear to be redundant, or unnecessary, while on the other hand it will be able to reiterate a set of instructions, either in the pre-determined number of cycles, or as long as a certain specified value, *e.g.* a value lower than a pre-determined error value, was obtained after the reiterative process. The operation of a computer consists, to the major extent, of a set of operations reiterated in cycles of a definite pattern. Consequently the programme chart will have to be laid down in such a way that at the corresponding moment of the progress of calculation the computer will be able to make a choice of the alternatives as the function of partial results, on hand of such a comparison.

E. g. on hand of formula

$$X_{1,2} = -\frac{b}{2a} \pm \sqrt{\left(\frac{b}{2a}\right)^2 - \frac{c}{a}}$$

the two roots of a mixed quadratic equation may be obtained accordingly, as under the root there stands

$$\left(\frac{b}{2\,a}\right)^2 \gtrless \frac{c}{a}$$

Consequently, when the discriminant is a real number, the computer causes the values of X_1 and X_2 to be typed out, on the other hand when there is a negative under the root, the machine will cause the real and imaginary terms of the result to be typed out separately, in the form

$$X_{1,2} = -\frac{b}{2\,a} \pm \sqrt{\frac{c}{a} - \left(\frac{b}{2\,a}\right)^2}\; j$$

An example of cyclic operation is offered by the solution of mixed cubic equations, further the calculation of logarithms as explained in Appendices 2 and 3, respectively.

The contact field of the programme chart has sixty rows each, formed of twelve contacts. However, since in addition to instructions for operations other indications, too, may be required, further since the programme chart may be used also for storing information related to the specific problem, the number of instructions assignable to a programme chart had to be limited to 45. In the event that calculation of a specific problem requires two programme charts, or even more, then the charts may be exchanged in a definite order, however, without the necessity of once again carrying in the starting data.

*

So far the computer has operated in a fairly convincing manner. After certain errors of principle, initial faults in design and assembly could be eliminated from the equipment, it appeared that the computer could operate with tolerable safety for any length of time. It was found that when the equipment had been laid off for a few days, errors would interlope in the calculations, *e. g.* owing to corrosions and dusting. However, generally after a problem or two were calculated the equipment returned to normalcy, and continued in this state. Even when the equipment failed to resume operations in a flawless manner, the presence of apparatus failures could be easily detected, on the appearance of gross errors. Failure tracing was made easy in first order by making use of the delayed action features incorporated in the equipment. *Routine* examples had been worked out involving the shifting of numbers to and fro between the units inside the computer, when use was being made of each of the memory units. At the completion of each step the partial results were typed out. It was found that preventive maintenance and failure tracing were made considerably easier by applying this method.

A number of programme charts were drawn up, which when calculation had been completed, substituted the results obtained into the original formula, so that any error would emerge. Even on calculations performed with a maximum of accuracy errors would occur mainly resulting from the translation of fractions, and also, because during the process in unit A values of less than 2^{-27} would overflow.

There is a point of some importance, however, which may not be self-evident, and which, therefore, requires particular consideration.

Actually telephone technics are in a state of revolutionary changes. These changes are closely related to the metamorphosis of switching technics into the science of the fundamental principles embodied by computers, and to the introduction of electronics into telephone technics.

The appearance of computers has effected radical changes in the general outlook of telephone technics. Earlier telephone technicians were wont to talk of switches, their functions, dial pulses, etc., there was talk of traffic as a measurable quantity, which might be routed or transacted at certain definable losses. To-day the vernacular of telephone technics has come to be the connotation of the terms of computer technics. Technicians speak of informations, their methods of storing, circuits have come to be based on logical relations, there are "And" or "Or" circuits, gate circuits, circuits known from pulse technics, while the building elements in first order are semi-conductors or ferrites.

The Hungarian telephone industry may now look back to a past of six decades at least, and may be called on to lend a hand in tackling the momentous problems the future has in store. One of these is the development of a telephone exchange type built up entirely of electronic elements. Although this problem is being worked on within the framework of the Council of Mutual Economic Aid, and with the participation of the competent organs of friendly countries, nevertheless Hungary's share in the work is rather substantial, and the country's resources are heavily taxed for both manpower and financial means. It is the task of the telecommunication chairs of the Technical University to take a hand in this work, and train a staff of highly skilled engineers equipped with the knowledge enabling them to stand the mettle.

The essence of this educational work is to inculcate in the minds of those graduating as engineers *a novel conception of switching technics.* A useful aid in this training work is the computer just completed. By means of the computer solutions of certain *logical problems* may be visualized, and the trainees may then be led *to look upon the new problems of telephone technics from a more elevated level of switching technics.* They may then be convinced of imbuing the spirit of these new vistas opened for the art of telecommunication, and thus become equal to the duties future keeps in store for them.

With these considerations in mind we can only be glad that the scheme could be translated into physical reality. For this achievement I should like to give thanks on behalf of the Chair, and also on my behalf to the Technical Division of the Academy, for the valuable aid extended to the promoters of the scheme and also for the very effective assistance of the superior authorities of the Polytechnical University.

IV. Appendices

Appendix 1

Arithmetical unit

An adding unit should be designed so as to conform to the block schematic in Fig. 7. Of units of this type there are 2 × 27 in series. Between any of these units and any other there is a link each. Each unit has three inputs (A, B, C_{i-1}) and two outputs (S, C_{i+1}).

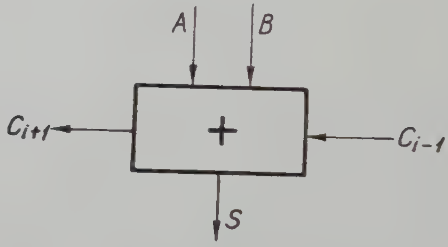

Fig. 7. Block schematic of the adding unit

Earth appears on point C_{i-1} of unit i coming from unit i—1, provided there is a carry-over. In like manner i applies earth to unit $i + 1$ over lead C_{i+1} when there is a carry-over after addition has been performed in unit i. A and B are the two numbers to be added, and S is the result of addition.

Each terminal may take on two conditions, *viz.* they may be either earthed, or off earth, or, with the notation of switching algebra, their state may be expressed as 1 or 0. The conditions may be tabulated as follows :

Inputs			*Outputs*	
A_i	B_i	C_{i-1}	S	C_{i-1}
0	0	0	0	0
1	0	0	1	0
0	1	0	1	0
1	1	0	0	1
0	0	1	1	0
1	0	1	0	1
0	1	1	0	1
1	1	1	1	1

This table must be realized. With the notations as used in switching algebra the following may be written :

$$f(s) = A\bar{B}\bar{C}_{i-1} + \bar{A}B\bar{C}_{i-1} + \bar{A}\bar{B}C_{i-1} + ABC_{i-1}$$

after manipulating :

$$= (A\bar{B} + \bar{A}B)\,\bar{C}_{i-1} + (\bar{A}\bar{B} + AB)\,C_{i-1}$$

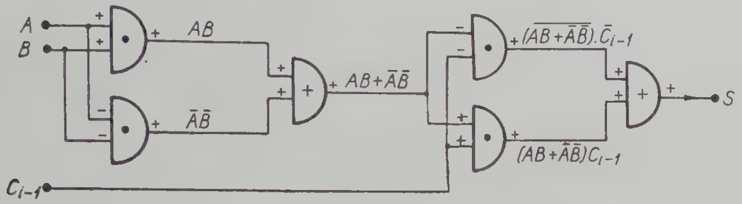

Fig. 8. Symbolic representation of the adding unit

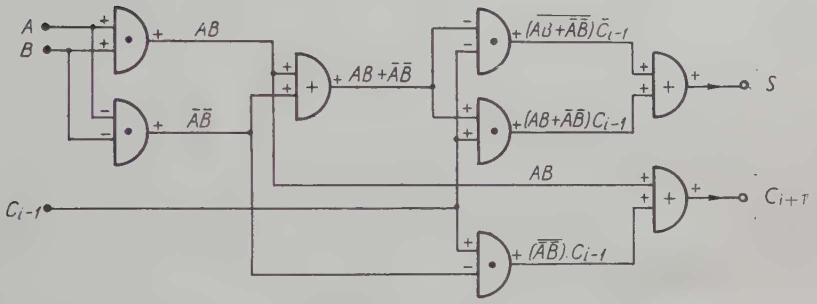

Fig. 9. Adding unit

whence after transformation :

$$(A\bar{B} + \bar{A}B) = (A + B)(\bar{A} + \bar{B}) = \overline{(AB + \bar{A}\bar{B})}$$

$$f(s) = \overline{(AB + \bar{A}\bar{B})}\,\bar{C}_{i-1} + (AB + \bar{A}\bar{B})\,C_{i-1}$$

The symbolic realization of this expression is shown in Fig. 8.

$$f(C_{i+1}) = AB + (A + B)\,C_{i-1}$$

and transformed :

$$= AB + \overline{\bar{A}\bar{B}}\,C_{i-1}$$

The realization of this expression completed by $f(s)$ is shown in Fig. 9.

The symbolic circuit in Fig. 9 may be realized with relays as follows: Input C_{i-1} and output C_{i+1} are each split into two terminals:

$$\begin{array}{ll} N_{i-1} & V_{i-1} \\ N_{i+1} & V_{i+1} \end{array}$$

on which earth will appear according to, if there is or not a carry-over or transfer.

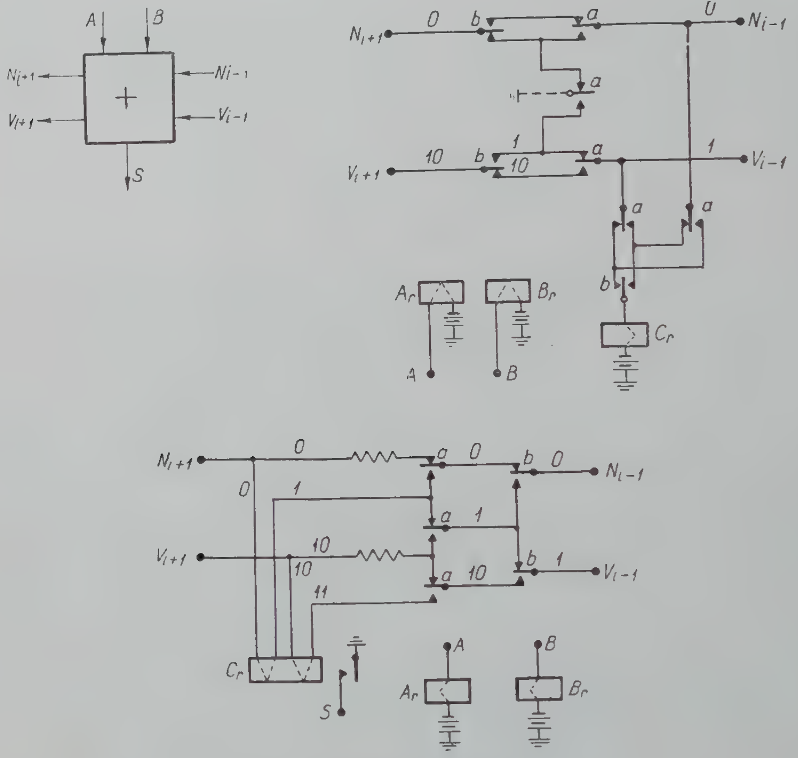

Fig. 10. Adding units with relays

The functions may be written as follows:

$$f(s) = \overline{(A\,B + \bar{A}\,\bar{B})}\,N_{i-1} + (A\,B + \bar{A}\,\bar{B})\,V_{i-1}$$

$$f(N_{i+1}) = \bar{A}\,\bar{B} + \overline{\bar{A}\,\bar{B}}\,V_{i-1}$$

$$f(V_{i+1}) = A\,B + \overline{\bar{A}\,\bar{B}}\,V_{i-1}$$

This solution is shown in Fig. 10, in two alternatives.

Appendix 2

Solution of a mixed cubic equation

A mixed cubic equation may be written in a reduced form as follows:

$$ax^3 + bx^2 + cx + d = 0$$

This equation has three roots, at least one of which is a real number. This real root is determined by way of iteration, then with the knowledge of the real root the cubic equation may be reduced to a quadratic form, so that the computer will be able to calculate the other two roots simultaneously, irrespective of whether they are real or conjugate complex numbers.

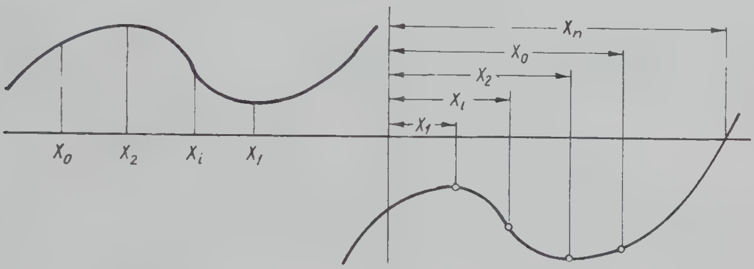

Fig. 11. Form of the function of a mixed cubic equation

An approach to the real root is by way of Newtonian iteration. The relation of two consecutive approximate values may be written as

$$X_{K+1} = X_K - \frac{f(X_K)}{f'(X_K)}$$

This cyclic operation then continues until

$$f(x_n) \leqq \delta$$

where δ is a pre-determined error value, and X_n the root wanted.

Let X_0 be the value where iteration starts. The first programme chart will then be used for determining the value of this X_0. When

$$a > 0$$

then the curve for the function may be plotted as shown in Fig. 11. (When $a < 0$ then the expression should be multiplied by -1.) Between $-\infty$ and X_1, or X_2 and $+\infty$ the function is of the increasing monotonic type. The real root may then be found in either of these intervals.

Extreme values X_1 and X_2 are obtained by differentiating the basic equation and making it equal to zero. Then

$$3\,ax^2 + 2\,bx + c = 0$$

The roots of this expression may be written as

$$x_{1,2} = -\frac{b}{3\,a} \pm \sqrt{\left(\frac{b}{3\,a}\right)^2 - \frac{c}{3\,a}}$$

further

$$x_i = -\frac{b}{3\,a}$$

which is the abscissa of the point of inflexion.

If $f(x_i) > 0$, then

$$x_0 = 2\,x_1 - x_i$$
$$= -\frac{b}{3\,a} - 2\sqrt{\left(\frac{b}{3a}\right)^2 - \frac{c}{3\,a}}$$

If $|f(x_0)| \leq \delta$, then x_0 is the real root wanted. Iteration begins in fact at x_0, and the result of this iteration will then be x_n. If x_n is known, the cubic equation may be reduced to $(ax^3 + bx^2 + cx + d) : (x - x_n) = Ax^2 + Bx + C$ where

$$C = \frac{-d}{x_n}$$

$$B = \frac{C - c}{x_n}$$

$$A = \frac{B - b}{x_n}$$

The roots of the quadratic equation will then yield the 2nd and 3rd roots of the mixed cubic equation.

Appendix 3

Calculation of logarithm

Any decimal number may be expressed as

$$N = M\,2^k$$

where

M denotes the mantissa of the number, and
k the binary characteristic (order of magnitude)

$$\log N = \log M + k . \log\ 2$$

where necessarily

$$1 < M < 2$$

The second term on the right side is easy to determine, since order of magnitude k is the result of conversion, and this has to be multiplied by the binary form of the value of

$$\log 2 = 0.30103 \ldots .$$

The logarithm of M may be determined by way of the following infinite series :

$$\ln M = \ln (1 + x) = \frac{x}{1} - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \ldots$$

where, when $x \ll 1$ then the series is a rapidly convergent one.
When

$$x = \frac{1}{8} \qquad \text{(0.001 in the binary system)}$$

then the 8th term will read

$$\frac{x^8}{8} = \left(\frac{1}{8}\right)^8 \frac{1}{8} = 2^{-27}$$

As the sum of the series of alternating signs may be written as

$$\sum_{k=9}^{k=\infty} (-1)^{k+1} \frac{x^k}{k} < \frac{x^8}{8}$$

and as the capacity of the computer is 27 binary digits, it will suffice to calculate the series up to the 8th term.

Let M in its binary form be divided by numbers easy to handle, *e.g.*

$$\alpha = \frac{3}{2} \left(= 1 + \frac{1}{2} = 1.1 \quad \text{in the binary form}\right)$$

$$\beta = \frac{5}{4} \left(= 1 + \frac{1}{4} = 1.01 \quad \text{in the binary form}\right)$$

$$\gamma = \frac{9}{8} \left(= 1 + \frac{1}{8} = 1.001 \ \text{in the binary form}\right)$$

When $M > a$, then by dividing

$$M_1 = \frac{M}{a}$$

Let M_1 be compared with β. When

$$M_1 > \beta$$

then by dividing

$$M_2 = \frac{M_1}{\beta}$$

When

$$M < a, \text{ then } M_1 = M \ (a = 1) \text{ and}$$

$$\text{when } M_1 < \beta, \text{ then } M_2 = M_1 \ (\beta = 1)$$

Similarly when

$$M_2 > \gamma$$

then by dividing

$$M_3 = \frac{M_2}{\gamma}$$

After one, two, or three divisions :

$$x = \left(\frac{M}{a\beta\gamma} - 1\right) < \frac{1}{8}$$

Then, when three divisions are to be performed

$$M = a \, \beta \, \gamma \, M_3$$

The numbers which have not taken part in the operation are discarded. ($= 1$ and $\ln 1 = 0$.)

Accordingly,

$$\ln M = \ln a + \ln \beta + \ln \gamma + \ln M_3$$

or recast into a form suitable for programming :

$$x\left(\frac{1}{1}\right) - x\left(\frac{x}{1+1}\right) + x\left(\frac{x^2}{2+1}\right) - x\left(\frac{x^3}{3+1}\right) + x\left(\frac{x^4}{4+1}\right) - \dots$$

The logarithm wanted will then be

$$\log N = k \cdot \log 2 + \log e \, [\ln a + \ln \beta + \ln \gamma + \ln M_3]$$

The approximate time required for determining the logarithm may be expressed as

$$k \cdot \log 2$$

a single multiplication

$$M_3 = \frac{M}{\alpha \beta \gamma}$$

(two divisions, at most, suffice).

The calculation of the 8th term of the infinite series involves eight cycles, each cycle representing a multiplication, division and addition each.

Finally, the expression in square brackets represents four additions, while the calculation of the final result each a multiplication and addition.

Appendix 4

Calculation of Erlang's formula

In its conventional form Erlang's formula may be written as

$$P_v = \frac{\dfrac{y^r}{r!}}{1 + y + \dfrac{y^2}{2!} + \dfrac{y^3}{3!} + \ldots + \dfrac{y^{r-1}}{(r-1)!} + \dfrac{y^r}{r!}}$$

where y denotes the traffic in terms of hours, as handled by a number of

r link circuits, and

P_v denotes the percentage of y failing to engage a link circuit immediately.

In its conventional form the formula is not suitable for programming, for it may occur that

$$y > 100\text{, and}$$

$$r > 150$$

i. e. y^r exceeds the capacity of the computer.

The terms of the formula should therefore be divided by

$$\frac{y^r}{r!}$$

so that the formula boils down to

$$P_V = \frac{1}{1 + \dfrac{r}{y} + \dfrac{r(r-1)}{y^2} + \dfrac{r(r-1)(r-2)}{y^3} + \ldots + \dfrac{r!}{y^r}}$$

Programming of the nominator in this form is a simple matter, the calculation of each value representing a cycle each.

From term k of the nominator $(k + 1)$ will be derived :

$$N_{K+1} = N_K \frac{[r - (k - 1)]}{y}$$

E. g.

$$N_4 = \frac{r(r-1)(r-2)}{y^3}$$

$$N_5 = \frac{r(r-1)(r-2)}{y^3} \frac{(r-3)}{y} = \frac{r(r-1)(r-2)(r-3)}{y^4}$$

Finally,

$$N = \sum_{x=0}^{x=r} N_x \text{ and}$$

$$P_v = \frac{1}{N}$$

Appendix 5

Conversion by halving and doubling

Let *e.g.* 87.6875 be converted.

The integers are keyed into halving circuit F_1, the fractions into doubling circuit D_1. Fig. 12 shows how the digits vanish in course of halving and doubling, and how the binary form

1010111.1011

is obtained.

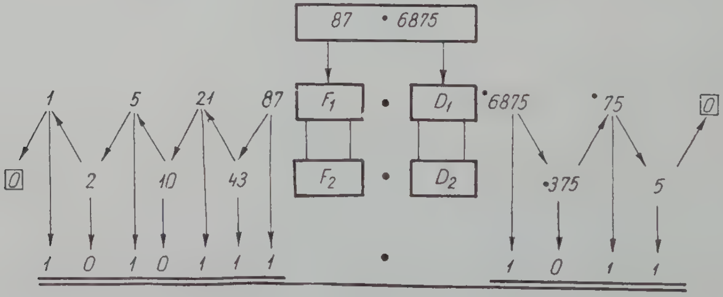

Fig. 12. Principle of conversion

Summary

A concise description of the digital computer of the Chair of Wired Telecommunication at the Polytechnical University of Budapest is here offered. This computer is an automatic programme controlled equipment, operating on the binary system and built up of electromagnetic relays. Each type of operation has been allotted a programme chart made of insulating material, with definite patterns punched in it, and suitable for electrical scanning. After the constants of the problem have been keyed into the computer, this will continue to operate in an automatic way in accordance with instructions, and cause an electromagnetically operated conventional typewriter to type out the results. The numbers are carried in and out in the decimal form, translation into, and retranslation from, the binary form being effected automatically.

The computer was primarily designed for didactic purposes, however, it is capable of tackling a great variety of mathematical problems. In the appendices the programming of a few simple problems has been described.

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STEINER TYPE INEQUALITIES IN PLANE GEOMETRY

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(Received May 17, 1959)

1

In the course of an investigation into the magnitude of the principal frequency Λ of a stretched membrane of area A and periphery L, it was found for a convex membrane that Λ can be appraised by the quantities A and L. To put it in more exact terms, if one seeks a solution of the partial differential equation

$$\Delta u + \Lambda^2 u = 0$$

u vanishing on the periphery of a convex plane domain D of area A, periphery L, the first principal frequency Λ satisfies the double inequality [8]

$$\frac{1}{2}\frac{L}{A} < \Lambda < \sqrt{3}\frac{L}{A}.$$

Apart from various applications of Courant's principle, not easily treatable in forms of concise inequalities, this double inequality is, as far as I know, the first simple two-sided — though admittedly not too sharp — existimation of the principal frequency of a membrane connecting it with geometrical data of the domain D. Moreover these data are the simplest geometrical quantities attached to a given plane domain.

If one wants to get rid of the restriction of the convexity of the domain D, one can see by means of examples that the left-hand side of the above double inequality fails to hold [9]. Yet one can show that

$$\Lambda < \sqrt{3}\frac{L}{A}.$$

for every membrane [9].

For showing this one has to prove an elementary geometrical property of plane figures, or more generally, plane point sets. Though this property

(Theorem I of this paper) can be expressed in quite simple terms and a partial analogy of it for convex domains was known to J. Steiner (and proved by quite elementary means) about a century ago, yet the demonstration of our theorem presented quite unexpected difficulties, mostly of topological nature.

These difficulties were later overcome, or rather, got round in an ingenious way by B. Szőkefalvi-Nagy, who gave an independent proof of Theorem I, to be published in the Acta Scientiarum Mathematicarum. His proof is self-contained, it does not rely on other results. Yet it seems worth while to present the following proof to show how closely the topics of this paper are interrelated with other investigations, notably with those of H. Hadwiger.

2

The outer parallel point set S_ϱ of a closed plane point set S is defined as the union of all closed circular disks of radius ϱ whose centres are points of S. The inner parallel point set $S_{-\varrho}$ ($\varrho < r$ where r is the radius of the greatest circle which can be inscribed in S) is the closure of the set of the centres of all those closed circular disks of radius ϱ which lie entirely in the interior of S.

The point sets S we shall deal with are all closed. We suppose throughout the whole paper for any point set to be met with, that their area A and the length L of their boundaries B exist in Minkowski's sense [10]. More precisely: if B' is a part of B, then the limits[1]

$$\lim_{\varepsilon \to +0} \frac{\text{area of } B'_\varepsilon S}{\varepsilon} \quad \text{and} \quad \lim_{\varepsilon \to +0} \frac{\text{area of } (B'_\varepsilon - S)}{\varepsilon}$$

exist and have the same finite value L', the length of the part B' of B. In particular

$$L = \lim_{\varepsilon \to +0} \frac{A - A_{-\varepsilon}}{\varepsilon} = \lim_{\varepsilon \to +0} \frac{A_\varepsilon - A}{\varepsilon}.$$

We suppose further that

$$\lim_{\varepsilon \to +0} L_{-\varepsilon} = \lim_{\varepsilon \to +0} L_\varepsilon = L. \tag{1}$$

---

[1] The notations A, B, L will be used consistently in such a manner that e.g. A_ε means the area of the set S_ε, $L^1_{-\varrho}$ the length of the boundary of the set $S^1_{-\varrho}$, $(B^1_{-\varrho})_\sigma$ the boundary of $(S^1_{-\varrho})_\sigma$ etc. Further we will denote by $C_s(T)$ a closed circular disk of radius s, centre T.

Other notations are as follows. If S_1, S_2 are point sets and P a point, then

$S_1 + S_2$ is the set of all those points which belong either to S_1 or to S_2;

$S_1 - S_2$ is the set of all those points of S_1, which do not belong to S_2;

$S_1 S_2$ is the set of all those points which belong simultaneously to S_1 and S_2 (the common part of S_1 and S_2);

$S_1 \subset S_2$ or $S_2 \supset S_1$ means that each point of S_1 belongs to S_2, too;

$P \in S_1$, $P \notin S_2$ means that the point P is an element of S_1, but not of S_2.

If S is a convex domain, then Steiner's equalities hold:

$$A_\varrho = A + \varrho L + \pi \varrho^2; \; L_\varrho = L + 2 \varrho \pi. \tag{2}$$

In search of the extension of the validity of Steiner's equalities, H. Hadwiger [4, 5] defined the notions of under-convexity and over-convexity. A closed point set S is said to be under-convex of degree a if for any $0 < \varkappa < a$ and for every point T of the plane, $SC_\varkappa(T)$, the common part of S and $C_\varkappa(T)$ is void or simply connected, yet if $\varkappa > a$ one can find at least one point T for which this is not true. If S is convex, its degree of under-convexity is ∞. We may extend the definition of under-convexity to $a = 0$ and say that the domain S is under-convex of degree 0 if to every $a > 0$ one can find a $\varkappa < a$ and a point T, so that $SC_\varkappa(T)$ consists of disconnected parts. (According to this, the degree of under-convexity of a non-convex polygonal domain is 0.) On the other hand S is said to be over-convex of degree β if $\bar{S}^*$, the closure of the complementary set S^* of S, is under-convex of degree β.

Hadwiger proved that if the simply connected closed domain S is under-convex of degree a and over-convex of degree β then (2) holds for $-\beta < \varrho < a$.

Another result of Hadwiger [4, 5] is, that if S is a simply connected domain, not containing infinity, then

$$A_\varrho \leqq A + \varrho L + \pi \varrho^2 \tag{3a}$$

and he calls it an inequality of Steiner's type. A similar formula follows from investigations of B. Sz.-Nagy [11] and G. Bol. [1]. They found that if S is a convex domain, then

$$A_{-\varrho} \geqq A - \varrho L + \pi \varrho^2 \quad (0 < \varrho < r) \tag{3b}$$

moreover $L_{-\varrho} \leqq L - 2 \pi \varrho$.

In the following we shall prove

Theorem I: If S is any simply connected domain, not containing infinity and subjected to the conditions given above, then

$$L_{-\varrho} \leqq L - 2 \pi \varrho \quad (\varrho < r) \;\; \text{(4a)} \quad \text{and} \quad L_\varrho \leqq L + 2 \pi \varrho \quad (\varrho > 0) \quad \text{(4b)}$$

from which (3a) *and* (3b) *follow for any simply connected domain* by an integration with respect to ϱ.[2]

---

[2] A relation substantially equivalent with formula (4b) — which has however no significance in the membrane problem mentioned in the introduction — was quite recently proved by G. Fast [12].

3

Consider the open set $\widetilde{S}_{-\varrho}$ of the centres of all closed circular disks of radius ϱ which lie in the interior of the simply connected plane domain S. The set $\widetilde{S}_{-\varrho}$ may consist of several disconnected parts $\widetilde{S}^{1}_{-\varrho}, \widetilde{S}^{2}_{-\varrho}, \ldots, \widetilde{S}^{n}_{-\varrho}$. The closure of $\widetilde{S}^{i}_{-\varrho}$ will be denoted by $S^{i}_{-\varrho}$ and termed a *component of the inner parallel point set* $S_{-\varrho}$ of S.[3] It is easy to see that any $S^{i}_{-\varrho}$ is a simply connected domain. We prove the following

Lemma I: if S is under-convex of degree α, then any component $S^{i}_{-\varrho}$ of $S_{-\varrho}$ is under-convex of degree at least $\varrho + \alpha$.

Suppose there exists a circular disk $C_{\varrho+\alpha-\varepsilon}(O)$ such that $S^{i}_{-\varrho}\, C_{\varrho+\alpha-\varepsilon}(O)$ consists of at least two disconnected parts. Then there are at least two arcs on the periphery of $C_{\varrho+\alpha-\varepsilon}(O)$ which do not belong to $S^{i}_{-\varrho}$ with the exception of their end points. It will be shown that if S is finite then each of these arcs can be connected with infinity by a path not going through $C_{\varrho+\alpha-\varepsilon}(O)$ i.e. $S^{i}_{-\varrho}$ is disconnected.

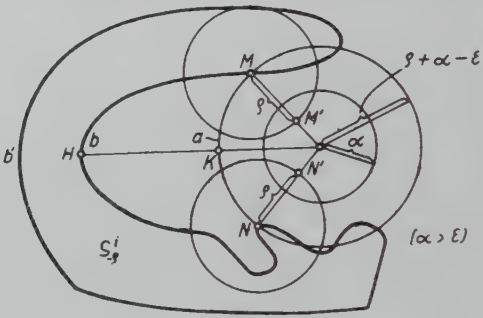

Fig. 1

For suppose the contrary. Let *a* be an arc of $C_{\varrho+\alpha-\varepsilon}(O)$ not belonging to $S^{i}_{-\varrho}$ excepted its end points M and N, from where one cannot attain infinity in the manner described above. M and N divide the periphery $B^{i}_{-\varrho}$ of $S^{i}_{-\varrho}$ in two parts b and b' one of which, say b, has the property that the finite domain bounded by b, OM and ON does not contain interior points of $S^{i}_{-\varrho}$. The half-ray from O, going through the middle point K of *a* should meet b at H.

We define the domain δ as the domain bounded by b, and the straight line segments OM and ON, and state that *B cannot have points in the interior of δ—$\delta\, C_{\alpha}(O)$*. For if P_0 were such a point, it could be connected with infinity by a path p_0 having no common point with S, excepted P_0. We distinguish two cases:

---

[3] Of course $S^{i}_{-\varrho}$ and $S^{j}_{-\varrho}$ $(i \neq j)$ may have common boundary points. It can be shown, that the number N of those points, which belong to at least two $S^{i}_{-\varrho}$'s is limited and a common upper limit of N and n is $A/(\pi\, \varrho^2)$.

1. If $a \leqq \varepsilon$ (this includes the case $a = 0$) then OM and ON are contained in $C_\varrho(M)$ resp. $C_\varrho(N)$, hence no point of them is outside S and p_0 cannot reach infinity from P_0.

2. If $a > \varepsilon$, let M' and N' be the points of intersection of OM with $C_\varrho(M)$ resp. of ON with $C_\varrho(N)$. Then p_0 has to intersect either OM' or ON' for MM' and NN' are in S. So $p_0\, C_a(O)$, if it exists, is not void, its points do not belong to S, and it divides $C_a(O)$ in at least two disconnected parts. One of these parts contains M' and the other N', as p_0 enters $C_a(O)$ on a point of the arc whose central angle is MON and leaves it finally through a point not belonging to this arc. The two points M' and N', both belonging to S, cannot be connected in the inside of $C_a(O)$ by a path lying entirely in $C_a(O)$. Hence $C_a(O)$ is a disk of radius a for which $SC_a(O)$ is disconnected, contrary to our assumption.

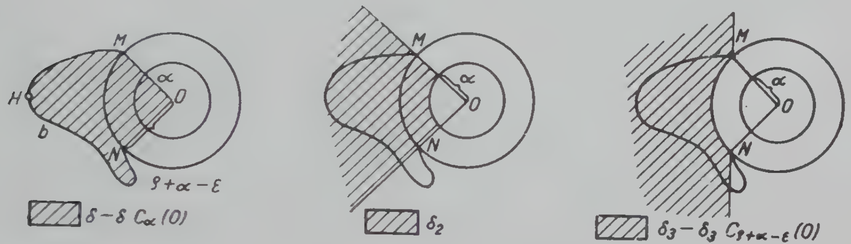

Fig. 2

Now we will seek a point P_H of B the distance of which from H is ϱ. We will see that such a point does not exist at all, *i.e.* H does not exist. We define the angular domain δ_1 as limited by the infinite rays from O, going through M, resp. N and containing K in its interior. P_H cannot be in $\delta_2 = \delta_1 - \delta_1 C_a(O)$. For supposing the contrary, it cannot be in $\delta - \delta\, C_a(O)$ so at least one interior point of the straight line segment $H P_H$ contains a point H' of $S^i_{-\varrho}$ which is impossible since $H' P_H < \varrho$.

Neither can P_H be in the interior of $C_\varrho(M)$ or $C_\varrho(N)$. But $\delta_2 + C_\varrho(M) + C_\varrho(N)$ contains the interior of the parallel point set of radius ϱ of the arc **a**. Hence $P_H K \geqq \varrho$.

Finally let δ_3 be the half plane limited by the straight line going through M and N and containing K. $P_H \notin \delta_3 - \delta_3 C_{\varrho+a-\varepsilon}(O)$ hence the angle HKP_H is greater than $\pi/2$ and as $P_H K \geqq \varrho$ it follows that $P_H H > \varrho$ in contradiction with the definition of P_H.

If the simply connected domain S contains infinity, a similar analysis shows that lemma I is true in this case too.

Recalling the definition of over-convexity we can now enounce

Lemma II. If S is over-convex of degree β, then any connected component S^i_ϱ of S is over-convex of degree at least $\varrho + \beta$.

4

We proceed now to the proof of formula (4a) in the case when S is under-convex of degree $\alpha > 0$. One can construct a component of its internal parallel domain $S_{-\varrho}$ by taking a circular disk of radius ϱ lying entirely in S and moving it continuously in every possible manner so that it remain always in the interior of S. (The moving disk must have no common points with B.) The part of the plane covered by the centre of the moving disk in its various positions is an open point set $\widetilde{S}^{\,1}_{-\varrho}$ and its closure is the component $S^{\,1}_{-\varrho}$ of $S_{-\varrho}$. The closure of the area covered by the whole disk is $(S^{\,i}_{-\varrho})_\varrho$. Clearly $(S^{\,1}_{-\varrho})_\varrho \subset (S_{-\varrho})_\varrho \subset S$. (Cfr. Hadwiger [3] p. 17.)

The boundary $(B^{-1}_\varrho)_\varrho$ of $(S^{\,1}_{-\varrho})_\varrho$ consists at least partly of points of B. If $(B^{\,1}_{-\varrho})_\varrho$ has other points too, it can be shown that these consist of circular arcs $a'_1, a'_2, \ldots, a'_h$ and the length of none of these arcs is greater than $\pi\,\varrho$.[4] The parts of B not common with $(B^{\,1}_{-\varrho})_\varrho$ will be denoted by $b_1, b_2, \ldots, b_h$ so that b_g and a'_g have common end points. The length of b_g is greater than that of a_g. For b_g connecting two points of the periphery of $C_\varrho\,(O_g)$, is outside of $C_\varrho\,(O_g)$, so it is longer than the shorter arc of $C_\varrho\,(O_g)$ connecting these same points.

It may happen that S_ϱ does not have other points than those of $S^1{}_\varrho$. Then using our lemma and Hadwiger's theorem on under-convex point sets, we conclude that

$$L \geqq (L^{\,1}_{-\varrho})_g = L_{-\varrho} + 2\,\varrho\,\pi$$

and have shown the inequality (4a) in the case when $S_{-\varrho}$ consists of one component only.

If, on the other hand, $S_{-\varrho}$ has other points too than those of $S^1_{-\varrho}$, let P_2 be one of them. Connect the point P_2 with $(B^1_{-\varrho})_\varrho$ by a curve lying in S and outside of $(S^1_{-\varrho})_\varrho$. The connecting curve ends in a point of the circular arc, say a_1' whose end points are P_1 and Q_1. Then place a disk of radius ϱ on P_2 and move it again in every possible manner, so that it should never have common points with B. We again get an open point set, say $\tilde{S}^2{}_{\varrho}$ which has no common point with $S^1_{-\varrho}$. Its closure is another component $S^2_{-\varrho}$ of $S_{-\varrho}$. Repeat this procedure until all components $S^2_{-\varrho}, S^3_{-\varrho}, \dots, S^n{}_{\varrho}$ of $S_{-\varrho}$ and their outer parallel domains $(S^2_{-\varrho})_\varrho, \dots, (S^n_{-\varrho})_\varrho$ are found.

---

[4] For let A_g be a point of $(B^1_{-\varrho})_\varrho$ not belonging to B and let $O_g \in S^1_{-\varrho}$ be the centre of that circle of radius ϱ whose periphery contains A_g. $C_\varrho(O_g)$ has to contain at least two boundary points of B, otherwise one could find in any neighbourhood of O_g a point $O'_\varrho \in S_{-\varrho}$ such that $C_\varrho\,(O'_g)$ would contain A_g in its interior. Let $P_g \in B$, $Q_g \in B$ be two points of $C_\varrho\,(O_g)$, such that the open arcs $\widehat{P_g A_g}$, resp. $\widehat{Q_g A_g}$ do not contain points of B. Then these arcs certainly belong to $(S^1_{-\varrho})_\varrho$ and the combined length of them cannot be greater than $\pi\,\varrho$. For, supposing the contrary, either the arc $\widehat{P_g A_g}$ or the arc $\widehat{Q_g A_g}$ is less than $\pi\,\varrho$ and one could find in any neighbourhood of O_g a point O''_g lying on the periphery of $C_\varrho\,(P_g)$ or of $C_\varrho\,(Q_g)$, such that $A_g \in C\ (O''_g) \subset (\tilde{S}^1_{-\varrho})_\varrho$. On the other hand O_g is perfectly determined as the nearest point of $S^1_{-\varrho}$ to the chord $P_g Q_g$ and it follows hence that no point of the arc $a'_g = P_g\widehat{A_g}Q_g$ can be an interior point of $S^1_{-\varrho}$.

We will use an induction for the proof of (4a) which was shown to be valid for $n=1$. We draw the chord P_1Q_1 connecting the end points of the arc a'_1. As $P_1Q_1 \leq 2\varrho$ no point of this chord lies in the interior of $S_{-\varrho}$. P_1Q_1 divides the interior of S in two parts Σ' and Σ'' both of which contain at least one, and so at most n—1 components of $S_{-\varrho}$. The parts of the boundary B belonging to Σ' resp. Σ'' will be denoted by B' resp. B'', their lengths by L' resp. L''.

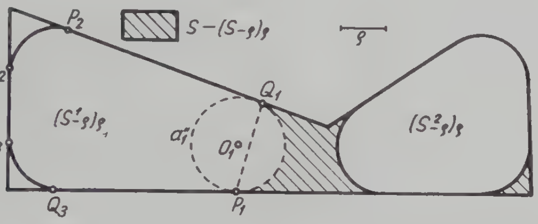
P_2
$S-(S_{-\varrho})_\varrho$
ϱ
Q_2
Q_1
$(S^1_{-\varrho})_\varrho$
a_1'
O_1
$(S^2_{-\varrho})_\varrho$
P_3
Q_3
P_1

Fig. 3

Note that by virtue of our construction that part of $S_{-\varrho}$ which lies in Σ' is entirely determined by B' and the remaining part of $S_{-\varrho}$ depends solely on the shape of B''. Hence we have a considerable liberty in deforming the curve B'' (B') into a new position B_0'' (B_0') so that the domain Σ_0' (Σ_0'') bordered by B' and B_0'' (by B'' and B_0') is such that $(\Sigma_0')_{-\varrho}\Sigma' = S_{-\varrho}\Sigma'$ $[(\Sigma_0'')_{-\varrho}\Sigma'' = S_{-\varrho}\Sigma'']$.

All that is wanted of B_1'' is that it should not have common points with the interior of the disk $C_\varrho(O_1)$. If this condition is fulfilled then there does not exist such a point $P' \in \Sigma'$ for which $C_\varrho(P')\,B' = 0$ and $C_\varrho(P')\,B_1'' \neq 0$.

If we denote by a_1'' that arc of the periphery of $C_\varrho(O_1)$ which completes a_1' to the whole circumference, then we may choose B_0'' to be the arc a_1''. Again there is no point P'' of Σ'' for which $C_\varrho(P'')$ has no common point with B'', but has a common point with a_1'.

So we conclude

$$\Sigma' S_{-\varrho} = [\Sigma' + C_\varrho(O_1)]_{-\varrho}$$

$$\Sigma'' S_{-\varrho} = [\Sigma'' + C_\varrho(O_1)]_{-\varrho}$$

Let us now denote the total length of the boundaries of $\Sigma' S_{-\varrho}$ and $\Sigma'' S_{-\varrho}$ by $L'_{-\varrho}$ and $L''_{-\varrho}$. As $\Sigma' S_{-\varrho}$ and $\Sigma'' S_{-\varrho}$ contain less than n components, we may use our inductive assumption and write

$$L' + L'' \leqq B' - 2\varrho\pi + B'' - 2\varrho\pi + 2\varrho\pi.$$

This is formula (4a) with the proviso that S is under-convex of degree $a > 0$.

If the degree of under-convexity of S is 0, then according to our lemma S_ε is under-convex of degree at least S_ε and as $S_{-\varrho} = (S_{-\varepsilon})_{-(\varrho-\varepsilon)}$ $(0 < \varepsilon < \varrho)$ (cfr. Hadwiger [3] p. 17) we can state that $L_{-\varrho} \leqq L_{-\varepsilon} - 2(\varrho - \varepsilon)\pi$. Using the formula (1) we have again (4a).

5

For proving the inequality (4b) we suppose at first that the simply connected closed domain S is over-convex of degree β and we construct its outer parallel domain S_ϱ by taking all closed circular disks of radius ϱ which do not contain points of S. The complementary set of the union U_ϱ of the centres of all these disks is S_ϱ.

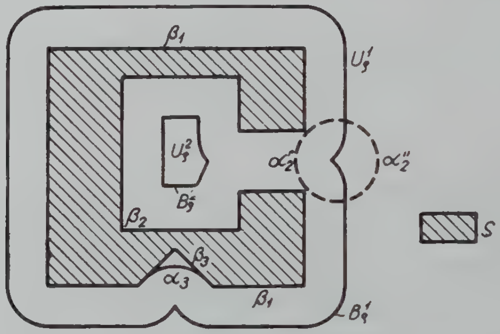

Fig. 4

First take a disk sufficiently far from S, and move it continuously in every possible manner so that it should have no common points with S. Then a simple connected part U_ϱ^1 of U_ϱ is constructed which extends to infinity. The boundary $B_{\varrho\varrho}$ of the closure of $(U_\varrho^1)_\varrho$ partly consists of points of B and it may happen that $B_{\varrho\varrho}$ contains other points too ; it can be shown that these lie on circular arcs $\alpha_2', \alpha_3', \ldots, \alpha_\lambda'$ of radius ϱ the central angle of which is at most π. Let $\beta_\varkappa$ be that connected part of B, which does not belong to $B_{\varrho,\varrho}$ and has common end points with $\alpha_\varkappa'$. The remaining part of B will be denoted by β_1. Obviously, β_λ is not shorter than α_λ hence the length $L_{\varrho\varrho}$ of $B_{\varrho,\varrho}$ is not greater than L.

If $U_\varrho^1 = U_\varrho$ we argue that the boundary B_ϱ of S_ϱ is the same as the boundary of U_ϱ and $L_{\varrho,\varrho}$ is the length of the boundary of the closure of $(U^*)_{-\varrho}$. Hence

$$L \geqq L_{\varrho\,\varrho} \geqq L_\varrho - 2\,\varrho\,\pi$$

and formula (4b) is proved if S_ϱ is a simply connected domain.

If B_ϱ, the boundary of S_ϱ consists of several disconnected parts, then one of these, say B_ϱ^1 is the same as the boundary of U_ϱ^1 and the others lie in the domains bounded by $\beta_\varkappa$ and $\alpha'_\varkappa$.

Deforming B in such a way that each $\beta_\varkappa$ is replaced by $\alpha_\varkappa$, and terming $S^{(1)}$ that point set, the boundary of which is the deformed boundary B, one sees that $S^{(1)}$ is the complementary domain of U_ϱ^1 and so $S^{(1)}$ is the inner parallel point set of radius ϱ of the closure of $(U^1)^*$. Let now $\alpha''_\varkappa$ be the circular arc which completes α'_k to an entire circumference. Denoting by $S^{(\varkappa)}$ the domains bounded by $\beta_\varkappa$ and $\alpha''_\varkappa$ it can be shown that the boundary of the inner parallel domain of radius ϱ of $S^{(\varkappa)}$ coincides with that part of B_ϱ, which is surrounded by $\beta_\varkappa$ and $\alpha'_\varkappa$. Using the letters $\beta_\varkappa$, $\alpha'_\varkappa$, $\alpha''_\varkappa$ for the notation of the length of these curves we have

$$L^{(1)} \leqq \beta_1 + \sum_\varkappa \alpha'_\varkappa + 2\,\varrho\,\pi$$

and

$$L^{(\varkappa)} \leqq \beta_\varkappa + \alpha''_\varkappa - 2\,\varrho\,\pi \qquad (\varkappa = 2, 3, \ldots \lambda)$$

By addition it follows

$$\sum_\varkappa L^{(\varkappa)} = L_\varrho \leqq L + (\lambda - 1) \cdot 2\,\varrho\,\pi + 2\,\varrho\,\pi - 2\,(\lambda - 1)\varrho\,\pi = L + 2\,\varrho\,\pi.$$

If the degree of over-convexity of S is 0, then we prove (4b) first for S_ε which is over-convex of degree at least ε. As $(S_\varepsilon)_{\varrho - \varepsilon} = S_\varrho$ $(0 < \varepsilon < \varrho)$ we have

$$L_\varrho < L_\varepsilon + 2\,(\varrho - \varepsilon)\,\pi\,.$$

Hence using (1), the inequality (4b) follows again.

6

These results can be generalized to domains of k-tuple connectivity. We have in this case

Theorem II. If S is a k-tuply connected domain, then

$$L_{-\varrho} \leqq L + 2\,(k - 2)\,\pi\,\varrho \qquad (\varrho \leqq r) \tag{5a}$$

$$L_\varrho \leqq L + 2\,\pi\,\varrho \tag{5b}$$

Hence it follows that *e.g.* for a ring-shaped domain $L_{-\varrho} \leqq L$.

For a k-tuply connected domain can be completed by the addition of $k-1$ simply connected domains, say $S_2, S_3, \ldots, S_k$ to a simply connected domain S_1. The length of the boundaries B_i of S_i will be denoted by L_i.

Now $S_{-\varrho}$ consists of all those points which are simultaneously part of $(S_1)_{-\varrho}$, $[(S_2)_\varrho]^*, \ldots, [(S_k)_\varrho]^*$ so

$$B_{-\varrho} \subset (B_1)_{-\varrho} + (B_2)_\varrho + \ldots + (B_k)_\varrho.$$

From this

$$L_{-\varrho} \leqq (L_1)_{-\varrho} + (L_2)_\varrho + \ldots + (L_k)_\varrho \leqq (L_1 - 2\pi\varrho) + (L_2 + 2\pi\varrho) + \ldots + (L_k + 2\pi\varrho) = L + 2(k-2)\pi\varrho.$$

The less informative inequality (5b) is derived essentially in the same way.

Both (5a) and (5b) are in a sense best possible inequalities. Let namely S be a circular disk, out of which $k-1$ circular disks of radius ε are cut out. If $\varrho < \varepsilon$ then $L_{-\varrho} = L + 2(k-2)\pi\varrho$ and if $\varrho > \varepsilon$ then $L_\varrho = L + 2\pi\varrho$.

7

A corollary of the inequality (4a) is the extension of the *isoperimetric inequality of Bonnesen* to non-convex domains, namely that if A is the area of a simply connected domain S, L the length of its periphery, r the radius of the greatest inscribed circle, then

$$L^2 - 4\pi A \geqq (L - 2\pi r)^2$$

or

$$A \leqq L r - \pi r^2. \tag{6}$$

This is special case of an inequality found by L. Fejes Tóth [2]. We use an argument due to Hadwiger [7] according to which $L_{-\varrho} \leqq L - 2\pi\varrho$ integrated in the interval $0 \leqq \varrho \leqq r$ yields

$$\int_0^r L_{-\varrho}\, d_\varrho \leqq \int_0^r (L - 2\pi\varrho)\, d\varrho$$

or as the left hand side of this inequality is A, we have (6).

Summary

The following theorem and its generalizations are proved under conditions specified in the foregoing paper.

Let S be a simply connected plane domain, L the length of its boundary, A its area. C_ϱ and $C_{-\varrho}$ are plane curves, not necessarily connected, lying outside and inside respectively of S, consisting of the set of points the nearest distance of which from the boundary points of S is ϱ. If L_ϱ and $L_{-\varrho}$ are the lengths of the curves C_ϱ and $C_{-\varrho}$ respectively, further A_ϱ and $A_{-\varrho}$ are the areas included by C_ϱ and $C_{-\varrho}$, then the inequalities (3a), (3b), (4a), (4b) hold.

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ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ НАУЧНОГО ИССЛЕДОВАНИЯ В ПРОМЫШЛЕННОСТИ*

Я. КЛАР

Исследование развития производительности труда представляет собой важный вопрос экономической литературы нашего времени. Кроме исследования его понятия, доклады занимаются его связями, планированием и всеми факторами, которые оказывают влияние на его развитие, изменение.

Среди факторов, влияющих на производительность труда, берется во внимание прежде всего вопрос *технического уровня.*

Хотя измерение изменения производительности труда встречает во многих случаях затруднения по разным причинам (в сущности оно возможно только в однородных отраслях промышленности), интересно рассмотреть из числа действующих факторов, взятых во внимание, значение научного исследования в промышленности, находящегося в тесной связи с повышением технического уровня, т. к. это способствует росту производительности труда.

Научное исследование в промышленности требует все больше квалифицированных рабочих сил и вместе с тем все больше материальных средств. Значит, даже с этой точки зрения не безинтересно, какова эффективность этой научно-исследовательской работы в отношении роста производительных сил, развития средств производства и производительности труда.

Рассмотрение эффективности научного исследования в промышленности само по себе — аналогично измерению изменения производительности труда — является сложной, многообразной задачей и во многих случаях очень трудно выразить это цифровыми данными. Ее подробным аналитическим исследованием как отечественная, так и иностранная специальная литература занимается сравнительно мало и уделяет ей меньше внимания.

Этот сравнительно малый интерес не может быть оправдан трудностью задачи и скромностью достигаемых результатов, потому что малозначительные частичные результаты, полученные при разных испытаниях, могут в значительной мере способствовать лучшему разрешению этого комплекса вопросов, до сего времени недостаточно выясненного.

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Тесная связь, которая, несомненно, существует между эффективностью научного исследования и ростом производительности, может быть целесообразно найдена постепенно.

Во-первых, следует отдельно выяснить более важные общие условия эффективности научного исследования; затем можно приступить к оценке того, как служит вообще исполнение этих условий росту производительности труда, и, наконец, как могут быть целесообразно измерены или выражены цифровыми данными явления, возникающие вследствие научного исследования в промышленности.

При рассмотрении более удобных условий экономической эффективности научно-исследовательской работы, прежде всего следует взять во внимание, что она имеет несколько экономических особенностей, отличных от производительной работы.

Так, например, 90% работы, обращенной на научное исследование, окажется безрезультатным, причем экономическое значение 10%, давших результат, может быть весьма велико.

При выполнении исследовательских работ часто бывает, что *о конечном результате нельзя заключить* с уверенностью, так как продолжительность некоторых исследовательских работ не раз бывает весьма велика. Из общеизвестного примера электронной трубки выясняется, что ее изобретение случилось приблизительно 50 лет тому назад. С открытия до крупнопромышленного производства истекло примерно 25 лет.

Оценка экономического результата успешной исследовательской работы часто может причинять трудности, ибо результат, происходящий как результат исследования во многих случаях может считаться не только результатом исследования, но, например, результатом изменения положения рынка, в капитализме же он может быть результатом поведения конкурента.

Наконец, *определение окончательно отрицательного результата* является часто трудным, так как не может быть точно определено, каковы те материальные и умственные затраты, с помощью которых исследование, кажущееся безрезультатным, может при определенном условии стать успешным. Киппнг в 1939 году сказал, что промышленное применение органических соединений кремния является безнадежным, и вот уже в 1948 году появились силаноны.

Наличие существенных особенностей научно-исследовательской работы, отличных от производственной работы, не означает невозможность исследования ее экономической эффективности — хотя бы в некоторых областях, но их следует учитывать.

Для частей исследовательской работы, подходящих экономической оценке (после соответствующего выделения неподходящих для этой цели частей), более важными условиями, *способствующими экономической эффективности* исследования — являются следующие:

1. Точное определение целей исследования, решение вопроса «что исследовать», что является основной задачей, связанной также с правильной разработкой общей экономической политики.

Вопрос «что исследовать» тесно примыкает к вопросу, *сколько средств* предоставляется для нужд исследования, потому что в интересах эффективного использования следует наметить столько исследовательских тем, для скольких на самом деле имеются в распоряжении соответствующие средства.

Целесообразие размеров научного исследования для производства изделий, может быть определено, например, спросом в новых продуктах, материальным положением заинтересованной отрасли промышленности, наконец перспективой запроектированной продукции на рынке.

2. Следующий вопрос — определение *методики* исследования, решение того «*как исследовать*».

В первую очередь, это является вопросом технической и научной организации.

Планировка организационных вопросов является работой заведующего исследованиями, а разработка частичных планов исследовательской работы является задачей отдельных исследователей.

Ради успеха заведующий исследованием должен, прежде всего, *разрешить основное противоречие исследовательской работы*. Оно заключается в том, что открытие, изобретение новых процессов и их разработка является в первую очередь вопросом личного таланта, способности, в то время как разработка подробностей результатов, их практическое техническое применение требует упорной коллективной работы, исходящей из требований плана.

Военная тактика и стратегия преподается по книгам, так изучают это также генералы. Но пробой генералов является не только их книжное знание, но то, *каким образом* применяют они свое знание в соответствии с их личной одаренностью и способностью.

Заведующему исследованиями следует также предоставить экономическую возможность для того, чтобы его сотрудники-исследователи могли развернуть свой личный интерес, следуя их способностям, в данном случае личному таланту, даже на тот случай, если это сопровождается риском определенных материальных средств, или расходами, которые иногда и не возмещаются, но нужно запретить всякие недисциплинированные попытки, скрывающиеся за такой маской, если это является только нереальным препровождением времени, явно противоположным организованной исследовательской работе.

3. В виду того, что технические науки вообще происходят от естественных наук и математики, т. е. стремятся к практическому применению последних, *весьма важным представляется* обеспечение целесообразного *сопряжения и соответствующей пропорции между так называемым основным и прикладным научным исследованием.*

Существует тесная взаимосвязь между исследовательской работой в области основных наук и территорией данной страны, плотностью ее населения, ее природными данными (как, например, обилие сырья или его недостаток). Определенные отрасли исследований в области основных наук, как например в области атомной физики и т. д. требуют значительных материальных затрат и большого числа выдающихся исследователей. *Значит, в отношении экономического последействия вопрос соответственной соразмерности между исследованием основным и прикладным исследованием в области промышленного применения является важным вопросом,* прежде всего в странах, где вследствие экономической мощности страны возможности исследований в области основных наук ограничены. Поддержка, затраченная или затрачиваемая на исследования в области основных наук, логически должна быть использована так, чтобы отпустить средства прежде всего *на прикладные исследования, связанные с основными исследованиями по промышленному* применению, а не на самопроизвольно избранные темы, не имеющие связи с последним. (От этого принципа можно отступить в надежде развития исследовательской культуры какой-либо страны, или же в надежде результата, ожидаемого от отдельных выдающихся ученых.) Это определение не относится к таким областям, которые являются чисто теоретическими, не требующими дорогостоящих приборов, оборудований, как, например, часть математических исследований или отдельные области теоретической физики и т. д.

4. *Выбор места организации* исследовательской работы тесно связан с ее экономичностью.

а) Основой научно-исследовательской работы и одновременно ее исходными пунктами являются университеты и научные институты. Пополнение исследователями лабораторий, самостоятельных исследовательских институтов и больших заводских лабораторий решается из года в год университетами, вследствие чего университеты занимают ключевую позицию в деле развития исследовательской работы всей страны.

Использование научной работы университетов является выгодным, так как все постройки, оборудование и персонал могут быть использованы *как для обучения, так и для исследований*. Далее, университеты предоставляют одиночную возможность — сравнительно дешево и хорошо — сочетать исследования в области наук с исследованиями прикладного характера путем содействия различных кафедр, значит, они обеспечивают всзможность идеального научного сотрудничества.

б) Если университеты представляют собой рабочие места идеального научного сотрудничества, осуществляемого в интересах исследования, то заводские *лаборатории крупнопромышленных предприятий могут создать идеальные условия сотрудничества для достижения хорошего экономического результата,* так как теория и практика, цель научного исследования и заинтересованность руководства предприятием, все обеспечивается в одном месте, в общей оценке.

в) Необходимость работы *самостоятельного промышленного научно-исследовательского института* возникает если речь идет о выполнении значительной исследовательской работы предприятий, не имеющих своей отдельной заводской лаборатории, или, если характер исследования требует кооперации больших научных коллективов и использования такого дорогостоящего и специального оборудования, установление которого в университетских институтах или в заводских лабораториях не является целесообразным.

Наконец, если речь идет о решении *вопросов, представляющих интерес нескольких отраслей промышленности.*

В области своих исследований самостоятельный исследовательский институт должен стать духовным центром своих заказчиков, который с одной стороны решает вверенные ему задачи и по мере обстоятельств проявляет инициативу.

5. Можно исследовать экономическую эффективность затраты средств, в первую очередь в ходе исследовательских работ, веденных более или менее продолжительное время (1—5 годов) для развития промышленного производства или производства нового продукта.

Экономичность этих работ зависит прежде всего от *правильной предварительной оценки результатов*, достигнутых при осуществлении отдельных фаз исследовательского плана, от постоянного сравнения уже затраченных или затрачиваемых, со средствами, необходимыми в будущем, т. е. от основательной оценки всех важнейших фаз исследовательской работы.

Оценка научно-исследовательских планов заключается в критике важных пунктов плана. Эти пункты следующие:

а) обеспечение соответствующего исследовательского персонала,

б) техническая осуществимость,

в) практическая пригодность и стоимость продукта,

г) емкость рынка,

д) результаты опытного завода.

В ходе анализа *технической осуществимости* нужно проверить прежде всего план лабораторных экспериментов. Следующим шагом является промежуточная проверка результатов и сравнение уже затраченных и затрачиваемых средств с дальнейшим результативным планом. В ходе проверки частичных результатов в каждом случае, когда это возможно, нужно составить прогноз необходимых до окончания работ средств, экономической стоимости конечного результата и вероятной продолжительности времени, необходимого для окончания исследования.

Предварительная оценка практической пригодности продукта является важной потому, что исследователи часто плохо знают связь теории с практикой. При проверке плана нужно стремиться к достижению согласия теории с практикой, идеи с осуществлением, технического совершенства с экономической полезностью.

При планировании исследования какого-нибудь нового продукта весьма *важную задачу представляет соответственное предварительное исследование спроса*, точное определение возможностей сбыта нового продукта.

6. *Возможности практического применения результатов* исследования отличаются друг от друга по отраслям промышленности и по предприятиям и зависят, прежде всего, от имеющихся в распоряжении материальных средств и инициативы (руководства предприятия) и отрасли промышленности.

а) Затрата средств для исследования и отдельные отрасли промышленности. Значение исследования, его необходимость является различной по отдельным отраслям промышленности, или по отдельным предприятиям. Значение его больше в тех отраслях промышленности, где исследование вообще может часто принести результат, который касается экономического положения всей отрасли. Вообще можно сказать, что значение исследования в тех отраслях промышленности, которые выросли из лабораторных открытий (химическая промышленность, медицинская промышленность) больше, чем, например, в машиностроительной промышленности, где совершенствование изделий может быть осуществлено частично эмпирическим путем.

Другое значение имеет исследование в таких отраслях промышленности, в которых сближение науки с производством не представляет возможности, где после завершения исследований следует окончательное *спроектирование* изделия ; но для проверки спроектированного нового типа нужно изготовить изделие *в его окончательной форме* (например, тип нового самолета). В этих отраслях промышленности после завершения исследовательских работ следует окончательное планирование изделия. Успех планирования в конечном итоге решается испытанием готового изделия.

Эффективность затраты средств на цели исследования может уменьшаться еще и по внешним причинам, а именно :

1. Если в отрасли промышленности, заинтересованной в ведении исследований, не установлено точно разработка каких процессов и производство каких продуктов необходимо.

2. Если исследователь под влиянием какого-либо срочного принудительного обстоятельства, возникшего в самой отрасли промышленности или вне ее, *работает, так сказать с одной минуты на другую*, вместо того, чтобы иметь в распоряжении достаточно времени, обеспеченного хорошо *продуманным планом.*

3. Может встретиться даже то, что затрата средств на исследовательскую работу окажется недостаточно эффективной по той причине, что у

новоорганизованной заводской исследовательской лаборатории или исследовательской группы нет достаточного авторитета, еще мало практических успехов, которые способствовали бы созданию необходимых условий для успешного завершения исследовательских работ.

б) Исследовательская работа и руководство предприятием. Организация практического применения исследовательской работы является важной задачей хорошего руководства предприятием. О нашем отечественном руководстве мы еще не в праве сказать, что большинство наших предприятий удовлетворяет этому требованию. Найдется еще такое предприятие, в котором еще не осознали срочность регулярной исследовательской работы в промышленности или важность внедрения результатов этой работы, в других предприятиях довольствуются тем, что время от времени выдвигают случайно или выдают на исследование по одной теме, которая часто не соответственно подготовляется, и рано или поздно констатируют, что затраченные на такую тему средства были напрасны.

Для того, чтобы исследовательская работа какого-нибудь предприятия достигла хороших результатов, нужно предварительно и точно сочетать возникающие научные вопросы технического характера с финансовыми возможностями предприятия, с ожидаемым хозяйственным результатом объекта (метода, продукта, изделия) исследования.

в) Если предположения, находящиеся в исследовательском плане, были оправданы лабораторной проверкой, то можно также определить вероятность технической осуществимости и практической пользы нового изделия, а если данные испытательного завода тоже благоприятны, то следует подробно проверить возможности и расходы, связанные с внедрением нового метода или крупнозаводского производства изделия. Для решения этого следует разобрать следующие вопросы:

а) величину необходимых заводских *капитальных вложений,*

б) эксплуатационные расходы производства, включая сюда тоже расходы, связанные с распространением, с продажей и т. д.,

в) общественную: экономическую: эффективность всех затрат и время оборачиваемости.

II.

Влияние результатов исследований на производительность труда

При изучении влияния результатов исследований на производительность труда, аспекты изучения расходятся в капиталистическом и социалистическом хозяйстве.

В условиях капиталистического хозяйства исследование в значительной мере является делом заинтересованных предприятий — если не считаться с отдельными исследовательскими работами всеобщего интереса, как, например, оборона, общая гигиена — и именно поэтому такое планомерное исследование, которое объединяло бы интересы всего народного хозяйства, за исключением только что упомянутых изъятий, является обыкновенно неосуществимым. Бесплановое исследование является спутником капиталистического хозяйства, которое с точки зрения всего народного хозяйства проявляет много очевидных экономических невыгод.

Кроме того, обсуждение эффективности исследовательской работы также неодинаково, так как отдельные капиталистические предприятия оценивают ее только в области оборота, прежде всего величиной роста их прибыли. Отдельные капиталистические предприятия могут считать эффективным, и такой результат исследования, который служит, например, только преодолению какого-нибудь из конкурентов.

В социалистическом хозяйстве исследованием в области основных наук, и перспективным исследованием в области прикладных наук (хозяйственная эффективность которых в это время едва ли может быть контролировано), руководит высшее руководство государством на основе заранее определенного плана и в соответствии с интересами всего народного хозяйства.

Более краткосрочное исследование в промышленности (например, развитие разных изделий, разработка новых методов и т. д.), экономическая эффективность которого обыкновенно может быть проверена, руководствуется также требованиями планового хозяйства на уровне как отраслевом, так и народно-хозяйственном и его эффективность оценивается значением хозяйственного результата, служащего интересам всего народа на упомянутых достижимых или достигнутых уровнях.

В нижеследующем будет упомянуто о связях, развивающихся в социалистическом хозяйственном строе между исследовательской работой в промышленности и производительностью труда.

Производительность труда может быть значительно повышена или понижена под действием нескольких *внешних факторов*, независимых от работы исследователей.

Таким фактором является, прежде всего, *технический уровень данной отрасли промышленности*, в которой используются достижения научного исследования. Поднятие сравнительно более отсталой от мирового уровня отрасли промышленности путем применения результатов исследования, конечно, представляет собой более легкую задачу, чем дальнейшее развитие такой отрасли промышленности, которая достигла мирового уровня или близка к нему. Но в случае сравнительно отставшей от мирового уровня отрасли промышленности вместо ведения исследовательских работ гораздо более целесообразно принятие необходимых патентов, плановых документаций и т. д. Кроме того, влияние результатов исследований на повышение производительности труда бывает обратно пропорциональным повышению технического уровня, другими словами: до тех пор, пока целью является дальнейшее развитие имеющейся технологии, при определенном уровне достижение даже небольших результатов сопровождается значительными затратами. Это положение остается действительным до тех пор, пока не наступит в связи с повышением технического уровня момент, когда дальнейший рост производительности труда с имеющейся технологией далее не может быть обеспечен. В таком случае следует перейти на новые пути, нужно подыскать новую технологию, для которой необходимы также исследования в области основных наук.

Такого рода внешним фактором является вопрос *современности оборудования* какого-нибудь *исследовательского института*. Чтобы удерживать оборудование на современном уровне — по данным мировой литературы — нужно годичное обновление, превосходящее 10% от общей стоимости оборудования. Если средства, необходимые для годичного обновления не имеются в распоряжении, то может возникнуть опасность, что работа исследовательского института, по независимым от него обстоятельствам, не является эффективной.

Со стороны научного исследования в промышленности в качестве дальнейшего внешнего фактора, влияющего на рост производительности труда, можно упомянуть еще *производственный* объем какой-либо *отрасли промышленности*. Другими словами это может быть выражено и так, что рядом с данной промышленностью нужно позаботиться об организации *соответствующего исследовательского института*. Ибо объем производства может быть решающим в том смысле, сооружение какого исследовательского института целесообразно, если уж необходимость такого сооружения возникла. Дальнейшее развитие отрасли промышленности, достигающей мирового уровня путем применения результатов исследования, обыкновенно требует создания *большого* исследовательского института, так как это представляет собой задачу более трудную, требующую значительных затрат средств. Значит, в данном случае вопрос стоит так: является ли эффективным создание такого института, с учетом объема производства изучаемой отрасли промышленности, значит, в данном случае решающим фактором является: способность объема производства отрасли промышленности покрыть расходы. Вот это следует сравнить с ожидаемыми результатами. Можно представить и такой случай, когда организация большого исследовательского института для отрасли промышленности будет эффективным только в том случае, если объем производства отрасли промышленности может быть значительно увеличен (например в рамках договора о хозяйственной взаимопомощи).

Со стороны научного исследования возможно и существование другого такого фактора, сказывающегося на производительности труда. Соответствующий учет этих факторов является предпосылкой того, чтобы сама по себе ценная и успешная исследовательская работа нашла выражение и в росте производительности труда.

Дальнейшая задача сводится к тому, чтобы определить: *когда, каким образом и где* можно измерить действие результатов научного исследования на производительность труда.

В связи *с первым* вопросом опыт в среднем мировом масштабе показывает, что на подготовку исследователей необходимо приблизительно пять лет, далее, что примерно 50% рабочей силы от общего числя занятых в исследовательской работе является способным для ведения исследовательской работы. Значит, требуется примерно десять лет, пока *в новых* исследовательских институтах возникнет необходимое количество соответственно подготовленных исследователей.

В связи *с вторым* вопросом, прежде всего с точки зрения измеряемости результатов следует различать два вида исследовательской работы, которые друг от друга коренным образом отличаются. Один вид можно бы назвать исследовательской работой, *сосредоточенной вокруг одной цели* (например, производство нового радиоаппарата или нового типа продукции); *другой же вид комплексный* в том смысле, что имеет несколько целей (например, исследование сплавов — между прочим и для радиоприемников). В обоих случаях общей характеристикой исследовательской работы является то, что результат всегда рассчитан на рост производства, понижение себестоимости, улучшение качества, независимо от того, происходит ли это путем повышения технического уровня или путем лучшего использования имеющейся мощности.

Измеряемость достижимых результатов формируется совершенно по другому в случае исследования, сосредоточенного на одну цель, и исследования, преследующего больше целей.

За каждым значительным результатом промышленного исследования, сосредоточенного на одну цель, на предприятии и в отрасли промышленности следует капиталовложение, необходимое для осуществления результата. Действие капиталовложения, которое вследствие результата промышленного исследования наступает как действие повышающее производство, понижающее себестоимость, т. е. улучшающее качество, *может быть измерено только у заказывающего предприятия или в отрасли промышленности* так, чтобы из всего капиталовложения выяснилась и эффективность вложений, приходящих на долю достижения результата исследования. Эффективность этого капиталовложения появляется в тех изделиях предприятия или отрасли промышленности, в интересах которых результат исследования был использован. Другими словами это можно выразить так, что эффективность действия исследования, сосредоточенного на одну цель, с целью повышения производительности труда, *может быть измерена только проверкой эконо-*

мической эффективности предприятия или отрасли промышленности, использующих результат исследования.

Действие результатов промышленного исследования, имеющего больше целей, на производительность труда очень трудно выразить, так как результат, например в производящем предприятии сказывается в гораздо меньшей мере, чем у всех дальнейших часто весьма многочисленных потребителей, которые приобретают данный продукт от производящего предприятия для своих целей, для своих изделий или продуктов. Например, какое-то предприятие в результате новейших исследований производит теплостойкий сплав. Экономический результат производства нового продукта на производящем предприятии проявляется обычно в меньшей степени, чем скажем на заводе газовых турбин, который для повышения кпд турбины раньше других заводов приобретает этот продукт.

Суммируя вышесказанное, при оценке действия результатов промышленного исследования на производительность труда следует учесть следующие точки зрения :

1. При оценке какого-нибудь результата по исследованию всегда нужно иметь в виду отношение технического уровня отрасли-потребителя к мировому уровню. Говорить о результатах исследования фактически эффективных можно только в таких отраслях промышленности, где технический уровень достигает мирового уровня. В таких отраслях промышленности, в которых технический уровень ниже мирового, в большинстве случаев целесообразнее вместо ведения исследовательской работы — если это только возможно — принять уже имеющиеся результаты путем покупки соответствующих патентов или плановой документации. В таком случае проводятся только те эксперименты, которые нужны для соответствующего отечественного применения.

2. Оценить цифровыми данными действие результатов исследования на рост производительности труда можно лишь в том случае, *если оно сосредоточено на одну цель*, а именно в том предприятии или в той отрасли промышленности, которые заказали или использовали такое исследование. В таком случае предприятие или отрасль промышленности должны прибавить к капитальным затратам, служащим производству какого-либо продукта или изделия, еще и валовые расходы по промышленному исследованию, необходимые для производства данного продукта или изделия и все капитальные затраты таким образом сравниваются с хозяйственными результатами, достигаемыми данным продуктом или изделием.

3. *Результат исследования, преследующего несколько целей*, может быть с трудом оценен цифровыми данными, поэтому его чаще всего делает высшее руководство отраслью промышленности для общего развития науки и его результаты используются на самых различных уровнях и для самых разнообразнейших целей. В сущности обсуждение результата такого иссле-

довательского труда совпадает с обсуждением результата в области основных наук, что экономически бывает едва оценимо.

4. Измеряемость *промышленной исследовательской работы, сосредоточенной на одну цель*, становится возможной также тогда, когда осуществление его *может быть* точно *планировано*, так как проведение таких работ может быть основано только на разработанных научных началах. Если же таких существующих, разработанных начал в данной исследовательской теме еще не имеется, то планированная исследовательская работа приобретает опять характер основно-научный, что по отношению к заказчику не дает возможности обеспечить соответствующий срок. Заказчик в таком случае не мог бы рассчитывать на то, что затраченные на исследовательскую работу средства, каким образом будут возмещены.

5. *Соотношение между исследованиям, и осредоточенными на одну и больше целей*, зависит прежде всего от технического уровня, степени развития и т. д. того предприятия или той отрасли промышленности, в интересах которых они ведутся.

В промышленности еще не достигшей мирового уровня — если это вообще необходимо — речь может идти, в первую очередь, об исследовании, сосредоточенном на одну цель. По мере того, как технический уровень какого-либо предприятия или отрасли промышленности достигает мирового уровня, иначе говоря, чем более сложная работа требуется на дальнейшее развитие их продуктов или их изделий, обыкновенно тем сложнее и многостороннее должно быть исследование.*

Третий, и в то же время *последний вопрос*: где можно оценить или измерить результаты исследовательской работы, влияющие на рост производительности труда. Из вышесказанного следует, что эти проверки нужно произвести на уровне *предприятия и отрасли промышленности*, а также на уровне *народного хозяйства*.

Исследовательские работы, сосредоточенные на одну цель, результаты которых при проверке эффективности продуктов или изделий использующего предприятия или отрасли промышленности, довольно хорошо подвергаются оценке цифровыми данными — можно измерить на уровне *пред-*

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* В связи с экономической эффективностью исследовательских работ следует отдельно остановится на неуместной практике, часто наблюдаемой также у нас, которую можно было бы назвать «повторным изобретением». Нередко бывает случай, что ведутся долговременные исследования на основе иностранных литературных данных со значительной затратой средств с целью производства такого изделия, которое может быть приобретено за девизу в готовом виде. Но опыт чаще всего подтверждает, что эти исследовательские работы, причиной которых является экономия девизы, в конечном итоге представляет собой для народного хозяйства более убыточное решение, нежели то, если бы путем затраты девизы мы привезли готовое изделие и на основе этого приступили к его отечественному производству. Не раз бывает, что такое «повторное изобретение» дороже и хуже подлинного. Несмотря на хозяйственный убыток, дальнейшим моральным недостатком этого решения является то, что такая деятельность расценивается как «исследовательская работа», которая на самом деле не что иное, как научная «халтура».

приятия или отрасли промышленности. Можно проверить результаты того-же исследования с точки зрения народно-хозяйственной эффективности.

Влияние на производительность труда результатов *исследовательской работы с несколькими целями* на уровне предприятия или отрасли промышленности, как правило, вовсе неизмеримо. В преобладающем большинстве случаев на уровне народного хозяйства можно оценить только их общее или принципиальное значение, но выразить их действие точными цифровыми данными почти невозможно.

Наконец, в домашнем отношении было бы необходимо поддержать более быстрое и широкое внедрение результатов научного исследования в заинтересованных отраслях промышленности путем соответствующих поощрений. Для достижения цели действительная в настоящее время премиальная система нуждается в поправках во многих отношениях.

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EQUIPMENT FOR WELDING ELECTRODE MANUFACTURING

By

M. MÁTRAY

Chief technologist

The designing and production of welding electrode manufacturing equipment has opened new vistas before the Hungarian machine building industry.

It is a highly significant feature of this equipment that its machines are also used in other fields of technique, but for the manufacturing of welding electrodes they had to be supplied with special devices. One might add that a major part of machinery used for the manufacture of welding electrodes consists of single-purpose machines developed parallel with the technique of electrode manufacturing. This applies, above all, to the so-called extruding machine which serves to provide the wire with its coating.

When analyzing the origin and the development of equipment for welding electrode manufacturing it is very interesting to note that it has been designed and built mostly in the welding electrode factories themselves.

The answer to this question can be found in the special requirements of welding electrode manufacturing. Production is anxious to meet the requirements of the rapidly developing welding industry ; it is possible only by putting welding electrodes of ever higher performance on the market. These efforts are usually connected with a development of coating formulae based on the available raw materials, without, however, altering to a greater extent the technique of coating mass manufacturing which depends on the extruding system. It means in other words, that the trends in the development of coating powders are influenced by the electrode manufacturing equipment. From this point of view it seems particulary advantageous when equipment for welding electrode manufacturing is produced by works disposing of both welding electrode manufacturing and machine building departments. The flow-sheet of an up-to-date welding electrode plant is shown on Fig. 1.

Welding electrodes have been produced in Hungary for 30 years. Their quality meets the world market standards, the different brands are exported to a series of countries. Their high quality is warranted not only by the up-to-date laboratories for product development and welding technique but also by an advanced production standard based on a suitable machine park. Types hitherto developed allow the series production of complete electrode manufacturing plants, both as regards their modernity and output.

Equipment for welding electrode manufacturing can be divided into four main groups, *i. e.* machinery for producing coating powders, machinery for wire processing, electrode extruding machinery and electrode drying equipment.

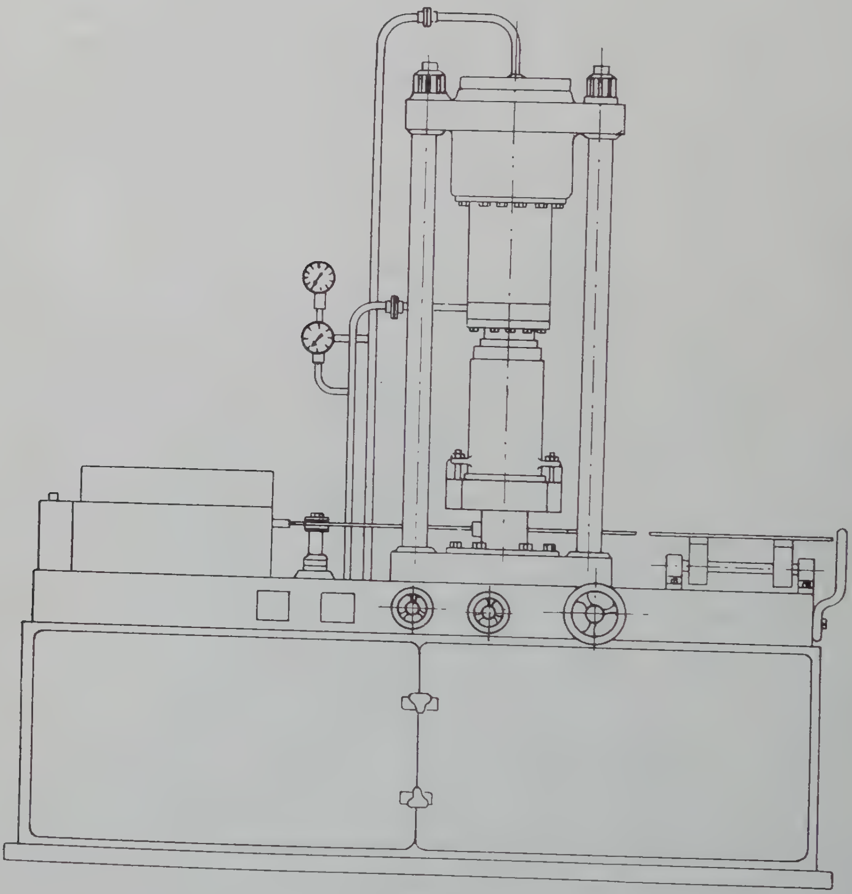

Fig. 1

Coating powders can be prepared either from ready-bought pulverized minerals or from lump ores. In case pulverized minerals are bought, only vibrating screens and powder-homogenizing machines are needed.

Vibrating screens suitable for producing coating powders are of a somewhat different size and design than other standard screening equipment. Vibrating screens are quite closed and, accordingly, run without causing dust. Besides, the quick replacement of the wire cloth is ensured. The size of sieving surface is given by the requirements of economical sieving of the finely ground powder constituents ; the economy of their performance is highly enhanced by adding a feeding device to the screen.

The Hungarian-made powder homogenizing machine is in principle a rotating drum of about 100 litres capacity, provided with a bladed wheel of special shape rotating in opposite sense. The bladed wheel lifts and lets back the coating powder the different constituents of which had been fed into the homogenizer.

This is made in a way to ensure the migration of all grains within the homogenizer space. A batch of 200 kgs powder shows an entirely homogeneous distribution after 5 minutes mixing when testing a component of any specific weight. Feeding and discharging of the machine is practically free from dusting.

If the coating powder is manufactured from lump ores the necessary equipment covers ore driers, crushers, screening and fine pulverizing machines as well as feeding and discharging devices for their continuous or batch-like operation. These machines and devices are the same as are in use for standard mineral pulverizing, thus their detailed description seems unnecessary in this paper. It should be mentioned, however, that the formation of dust has been largely eliminated with all powder-processing machinery, rather an important feature when considering the fine grain of the powders used for electrode manufacturing. It involves that dust impairing the health of the operators is eliminated. Such danger is signalled by automatic devices while the machinery is protected by safety protectors. An important point within the powder producing shop is also the economical handling of raw materials of various shapes and specific weight inside the shop. This problem can be solved by cranes or pneumatic devices, according to the capacity of the shop.

Wire processing starts from wire drawn to exact size and arriving in coils. The wire must be processed to very close tolerances regarding both straightness and length ; the cuts be clean of burrs. These requirements are very important since the concentricity of the coating during the extruding operation greatly depends on them. This is why the straightening machines for electrodes differ greatly from similar machinery used in standard wire processing. Perfect straightness of the wire is ensured by a suitable setting of the straightening jaws inside the straightening body as well as the several pairs of synchronously rotating wire-transporting rolls. Exact cutting lengths can be achieved only by cutting mechanism with forced operation and not with the standard stop mechanisms. A special device is also needed for attaining cutting surfaces without burrs, especially with the wire of a dia less than 4 mms. Besides, the tools must be also of best quality with lasting edges. The device ensuring cleanness from burrs is produced on client's special requests. Of all these quality requirements are observed that the wire straightening machines generally employed have an output about 50 per cent lower than that of the electrode extruding presses. Using the *single-purpose machines* developed for wire straightening and cutting, it was possible to step the output by about 20 per cent. By the use of auxiliary equipment, the down-times were considerably lowered, so these machines have, after all, a yield of nearly 75 per cent of the extruding presses.

Coating mass is manufactured by homogeneously mixing the coating powder with waterglass (solution of alkali silicate). For this operation, special mixers with two rolls and a disc rotating in opposite sense should be used since they work very satisfactorily and ensure within a very short period a consistency of the mass best suited for the extrusion operation.

The extruding press is the most important unit in welding electrode manufacturing. It is in this equipment that the coating mass is pressed onto the wire and the electrode assumes its final shape.

The electrode extruding press is in fact a complex aggregate consisting of several machine units : the press proper operated by mechanical or hydraulic power with its wire-feeding device, different transporting and distributing constructions and the equipment for forming the contact end of the electrode. The latter is necessary because the extruding press applies the coating onto the full length of the wire. The coating must be removed on a certain length to ensure contact of the electrode holder and it seems practical to do so while the mass is still in the plastic condition.

The most important requirement to be met by the extruding machine is to yield a coating which is smooth, continuous and adheres well to the wire. A most important factor is further the concentric position of the coating on the full length of the wire since the welding performance of the electrode depends highly on this fact.

From the many extruding presses, there are three principal types to be distinguished.

The first is characterized by the fact that the direction of movement of the mass and the wire include an angle of 90 degrees. These extruding presses are built in both vertical or horizontal design (see Fig. 2).

A characteristic of the second type is that the direction of movement of the mass and the wire include an angle of less than 90 degrees. These extruding presses are built usually in a horizontal design (see Fig. 3). The third type shows a coincidence of both directions of movement. It is the so-called co-axial extruding press and is built exclusively in a horizontal design.

With all these three extruding presses the coating mass is forwarded either by mechanical worms or by hydraulic pistons, but in any case periodically. The extruding presses described above show a different rate of mass flow thus affecting in varying degrees the concentricity of the coating. According to the laws of fluid mechanics, the flow properties of the coating mass can be expected to be most favourable when the section of the extruding tool is decreasing so gradually that it secures a steady speed of the mass flow. This may be achieved if friction along the walls of the extruding toll and within the particles of the mass may equalize. This can be ensured best by the extruding press types showing an angle of less than 90 degrees between the direction of movement of the mass and the wire or even a coincidence of these two directions. In Hungary extruding press type with an angle of 36 degrees is being used at present.

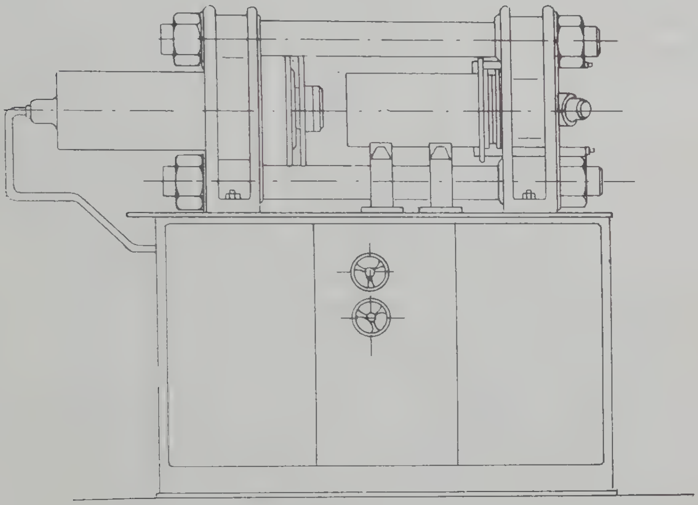

Fig. 2

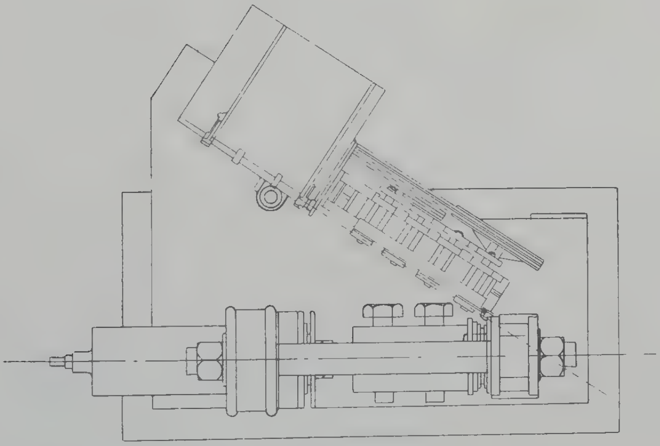

Fig. 3

The mass is pressed onto the wire by a hydraulic equipment.

Subsequent electrode plants are expected to be equipped also with extruding presses working on the principle of screw conveyors. A principle of these machines can be seen on Fig. 4. It shows the following advantages :

The axis of mass-forwarding coincides exactly with the axis of the wire to be coated,

the mass is forwarded continuously and without changes of direction, thus the concentricity of coating is ensured as far as possible,

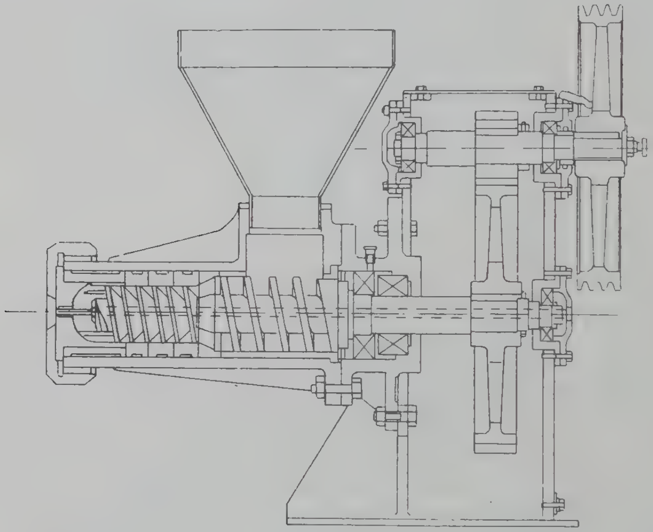

Fig. 4

the extruding press is operating continuously, ensuring a production increase of about 20 per cent, when compared to the periodically operating extruding press,

costly auxiliary equipment (mass cylinders) and mass briquetting equipment, necessary with other press types, can be dispensed with since this press can be fed with mass of no shape whatever.

As compared to extruding presses with hydraulic equipment, pumping equipment with its costly running and maintenance expenses can be omitted. The weight and place requirement of the extruding press is considerable decreasing.

Summing up, one may see that the mechanically operated screw-conveyor electrode extruding press is the most up-to-date and, at the same time, it is the most simple welding electrode manufacturing unit, developed by the use of experience gathered by Hungarian electrode manufactures over three decades. After the operation of electrode extrusion, the coating has a humidity of 6—8 per cent to be lowered by drying to a figure of 1.0—0.5 per cent. After extrusion, the coating is still in a plastic condition and can be easily damaged, therefore it is important that no mechanical force is acting on it during drying. It is not advisable to dry electrodes piled up in several layers. A further important requirement is the uniform heat transfer to the full coating surface during drying.

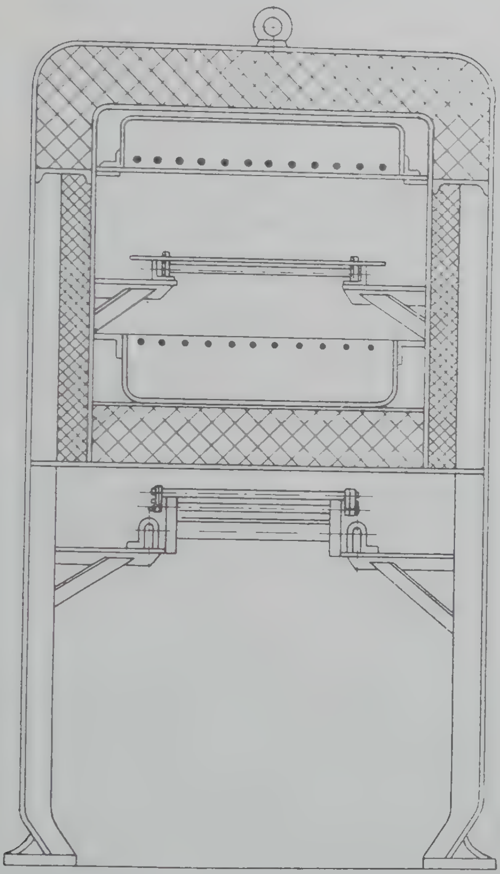

Fig. 5

Up-to-date electrode drying equipment has a powerful heating source which may be sensitively and gradually controlled within the necessary temperature ranges. The heating equipment consists of dark radiating electric heating tubes. Owing to the special design of the heating tubes, they have a long operating life. These tubes have a power consumption as low as 60—65 per cent of standard resistance-heated equipment. The electrodes are forwarded by an infinitely variable continuous conveyor. The distance between the individual electrodes may be predetermined and thus the output of the aggregate synchronized with the output of the extruding press. In a section of the drying part, the igniting end of the electrode is formed. The whole aggregate has a length of about 30 metres. This relatively short drying path could only be reached by the use of dark radiating electric heating tubes. Owing to its simple design, the drying equipment needs no special handling or maintenance, and electrodes of all usual lengths may be treated on this equipment (see Fig. 5).

The main electrode manufacturing units discussed above show the trends in modern Hungarian electrode manufacturing. Under the production programme, there are further to be found auxiliary equipments such as complete crushing, pulverizing and grading machinery, special powder storing and feeding devices, together with adjoining material handling facilities. It should be especially stressed that in the course of designing the powder processing and forwarding equipment special care was paid to avoid the dust formation, caring hereby for the health of the operators (coating powders include the danger of silicosis and manganese poisoning).

The use of up-to-date controlling and measuring instruments deserves special attention. Among these, just one type should be mentioned: the instrument determining continuously the dielectric constant of the coating and determining hereby quickly and simply its moisture contents. This instrument is also produced as a portable type for shop purposes and allows frequent control both in the electrode manufacturing works and at the consumer's.

With respect to the limited space, this paper could not aim at a detailed description of the mentioned electrode manufacturing equipment. Specialists will be able to see from the details given that Hungarian craftsmen know how to cope with their problems and are familiar with the latest trends on a world scale. It was not without importance to consider these problems since the consumption of electrodes has increased these last five years, even in the most advanced industrial countries, by yearly 8—10 per cent. This is given by the ever increasing application of arc welding, in spite of the many automatic arc-welding processes already in use. Design and execution of modern welding electrode manufacturing equipment of Hungarian origin has not been restricted, as can be seen, to the development of single machines or aggregates. On the contrary, the greatest efforts have been made to elaborate a manufacturing technology for welding electrodes meeting the welding requirements of to-day. This paper has been written with the aim to call the attention of all those interested in the performance and the level attained in Hungary and at the same time to make our readers visualize the modernity of our manufacturing equipment.

BOOK REVIEW — BUCHBESPRECHUNG

Recent Advances in Atmospheric Electricity

Editor : L. G. Smith, M. A., Ph. D.

Pergamon Press, 1958. 631 p. 425 Figs.

The book contains 59 papers and short contributions, as well as discussions on them, i. e. the proceedings of the Second Conference on Atmospheric Electricity held at Portsmouth, New Hampshire, May 20—23, 1958. Being published in September of the same year, it ought to be praised as a top performance of editing efficiency. It is well known to people who have confronted the job of publishing the material of a conference with so many lecturers how much work is needed for making from the lectures a publication in form of a book ; I think that such people might be able to appreciate the work of the coordinator, in this case the Wentworth Institute, and also that of the Pergamon Press.

So I believe that this extraordinary performance in itself would deserve a digest longer than usual. But there is yet another reason for a longer review : if we want to inform our readers as completely as the topic and the book deserve, we have to enumerate the authors and the titles of all papers and contributions which are to be found in the book. After this, we will point out some of them, which seem to be of particular interest to electrical engineers.

The proceedings are divided into three parts : fair weather electricity, thunderstorm electricity and lightning discharges.

The papers and contributions in these three groups are as follows :

I. Fair weather electricity

1. E. T. Pierce : Some Topics in Atmospheric Electricity.
2. P. J. Nolan : Small Nuclei Produced by Discharge at a Point.
3. R. C. Sagalyn : The Production and Removal of Small Ions and Charged Nuclei over the Atlantic Ocean.
4. L. W. Pollak and A. L. Metnieks : The Diffusion Coefficient of Large Ions.
5. G. A. Faucher : A Study of Air Flow in a Large-Ion Chamber.
6. J. F. Clark : The Fair-Weather Atmospheric Electric Potential and its Gradient.
7. J. H. Kraakevik : Electrical Conduction and Convection Currents in the Troposphere.
8. S. P. Venkiteshwaran : Measurement of the Electrical Potential Gradient and Conductivity by Radiosonde at Poona, India.
9. L. Koenigsfeld : Observations on the Relations between Atmospheric Potential Gradient on the Ground and in Altitude, and Artificial Radioactivity.
10. H. O. Curtis and M. C. Hyland : Aircraft Measurements of the Ratio of Negative to Positive Conductivity.
11. H. Hatakeyama, J. Kobayashi, T. Kitaoka and K. Uchikawa : A Radiosonde Instrument for the Measurement of Atmospheric Electricity and its Flight Results.
12. H. W. Kasemir and L. H. Ruhnke : Antenna Problems of Measurements of the Air-Earth Currents.
13. H. Israël : The Atmospheric Electric Agitation.
14. M. Kawano : The Local Anomaly of the Diurnal Variation of the Atmospheric Electric Field.
15. R. Reiter and M. Reiter : Relations between the Contents of Nitrate and Nitrite Ions in Precipitations and Simultaneous Atmospheric Electric Processes.
16. H. Dolezalek : Problems in Atmospheric Electric Synoptic Investigations.
17. R. Mühleisen : The Influence of Water on the Atmospheric Electrical Field.
18. R. H. D. Barklie, W. Whitlock and G. Haberfield : Observations of the Reactions between Small Ions and (a) Cloud Droplets, (b) Aitken Nuclei.

Contributions

19. H. Israël : The Man-made Radioactivity of the Atmosphere at Aachen on April, 1, 1958 and its Origin.
20. O. C. Jones, R. S. Maddever and J. H. Sanders : Radiosonde Measurements of Vertical Electric Field and Conductivity in the Lower Atmosphere.
21. R. C. Sagalyn : Significance of the Ratio of the Polar Conductivities in Regions of Variable Pollution Content.
22. G. P. Serbu : Atmospheric Electricity and Advection Fog Forecasting.
23. D. L. Harris : Atmospherie Artificial Radioactivity.

Thunderstorm Electricity

1. D. R. Fitzgerald and H. R. Byers : Aircraft Observations of Convective Cloud Electrification.
2. Y. Tamura : Investigations on the Electrical Structure of Thunderstorms.
3. S. Chapman : Corona-Point Discharge in Wind and Application to Thunderclouds.
4. H. Hatakeyama : The Distribution of the Sudden Change of Electric Field on the Earth's Surface due to Lightning Discharge.
5. L. G. Smith : Electric Field Studies on Florida Thunderstorms.
6. B. Vonnegut and C. B. Moore : Preliminary Attempts to Influence Convective Electrification in Cumulus Clouds by the Introduction of Space Charge into Lower Atmosphere.
7. C. B. Moore, B. Vonnegut and A. T. Botka : Results of an Experiment to Determine Initial Precedence of Organized Electrification and Precipitation in Thunderstorms.
8. R. M. Cunningham : Cumulus Circulation.
9. P. B. MacCready Jr.: The Lightning Mechanism and its Relation to Natural and Artificial Freezing Nuclei.
10. M. Brook : Laboratory Studies on Charge Separation During Ice-Ice Contact.
11. J. P. Kuettner and R. Lavoie : Studies of Charge Generation During Riming in Natural Supercooled Clouds.
12. B. Vonnegut and C. B. Moore : Giant Electrical Storms.
13. P. B. MacCready Jr.: Equipment for Forecasting Lightning Danger.

Contributions

14. J. A. Chalmers, J. E. Maund and J. W. Milner : Recent Results on Point Discharge.
15. T. W. Wormell and C. J. Adkins : Effects of Splashing of Raindrops at the Ground.
16. J. C. Williams : Some Properties of the Lower Positive Charge in Thunderclouds.
17. V. J. Schaeffer : The Electrification of Oil and Water Clouds.
18. R. Reiter : Observations on the Electricity of Nimbo-Stratus Clouds.

III. The Lightning Discharge

1. D. Atlas : Radar Lightning Echoes and Atmospherics in Vertical Cross-Section.
2. C. E. R. Bruce : Terrestrial and Cosmical Lightning Discharges.
3. E. L. Hill : Free Electrons in the Lower Atmosphere.
4. M. M. Newman : Lightning Discharge Channel Characteristics and Related Atmospherics.
5. N. Kitagawa and M. Kobayashi : Tidal-Changes and Variations of Luminosity due to Lightning Flashes.
6. H. Norinder and E. Knudsen : Combined Analysis of Daylight Photographs of Lightning Paths and Simultaneous Oscillographic Records.
7. H. Norinder, E. Knudsen and B. Vollmer : Multiple Strokes in Lightning Channel.
8. H. L. Jones : The Identification of Lightning Discharges by Spheric Characteristics.
9. D. J. Malan : Radiation from Lightning Discharges and its Relation to the Discharge Process.
10. A. Kimpara : Atmospherics in the Far East.
11. H. Ishikawa and A. Kimpara : Lightning Mechanism and Atmospheric Radiation.
12. C. G. Stergis and J. W. Doyle : Location of Near Lightning Discharges.
13. R. E. Holzer : World Thunderstorm Activity and Extremely Low Frequency Spherics.
14. M. J. Large and T. W. Wormell : Fluctuations in the Vertical Electric Field in the Frequency Range from 1 Cycle per Second to 500 Cycles per Second.
15. W. L. Taylor and L. J. Lange : Some Characteristics of VLF Propagation Using Atmospheric Waveforms.
16. H. W. Curtis : The Nature of Lightning Discharges which Initiate Whistlers.

Closing Remarks by P. H. Wyckoff.

Among the papers quoted above, the following seem to be of particular interest to electrical engineers :

I. 1. about the currents flowing in the lightning return stroke, which is given by the formula

$i_t = i_0\,(e^{-\alpha t} - e^{-\beta t})$
with $i_0 = 28\,.\,10^3$ A,
$\alpha = 7\,.\,10^3$
and $\beta = 4\,.\,10^4$
as parameters.

I. 21. about fog forecasting.

II. 2. about investigations on the electrical structure of thunderstorms.

II. 4. about the distribution of the sudden change of electric field on the earth's surface due to lightning discharges.

II. 12. about giant electrical storms.

II. 13. about an equipment for forecasting lightning discharges (also very interesting for many branches of industry handling explosives and fuels etc.). The equipment described has been found to be capable of giving usually a 20—90 minutes warning of dangerous lightning conditions.

III. 2. about terrestrial and cosmical lightning discharges.

III. 7. about the multiple strokes in lightning channels.

III. 11. about lightning mechanism and atmospheric radiation.

III. 12. about the location of near lightning discharges.

III. 16. about the nature of lightning discharges which initiate whistlers.

We think that this brief survey is sufficient to show how much interesting information is given in the present book, which will be useful in a wide field of industry and science.

Prof. J. Eisler, El. Eng., D. Eng., D. Sc.

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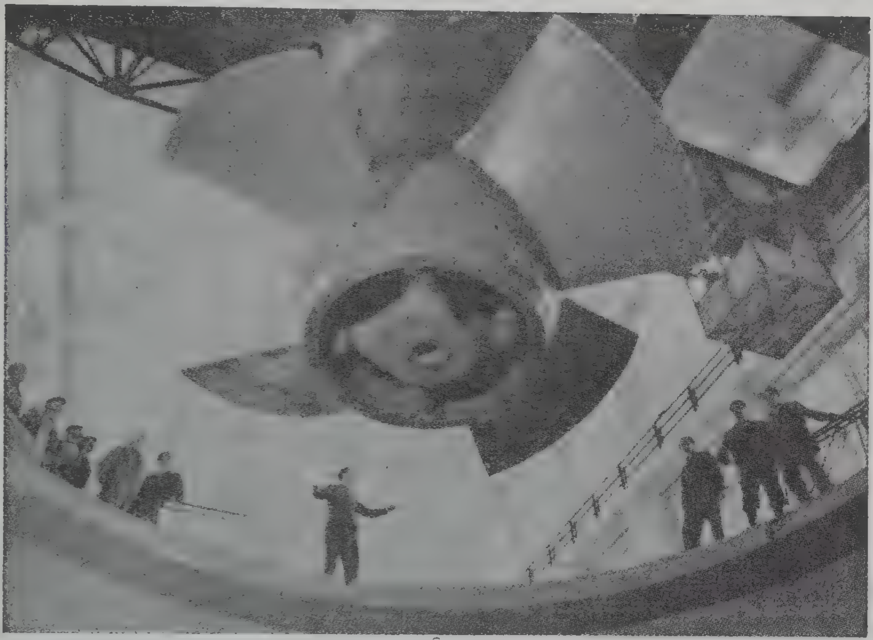

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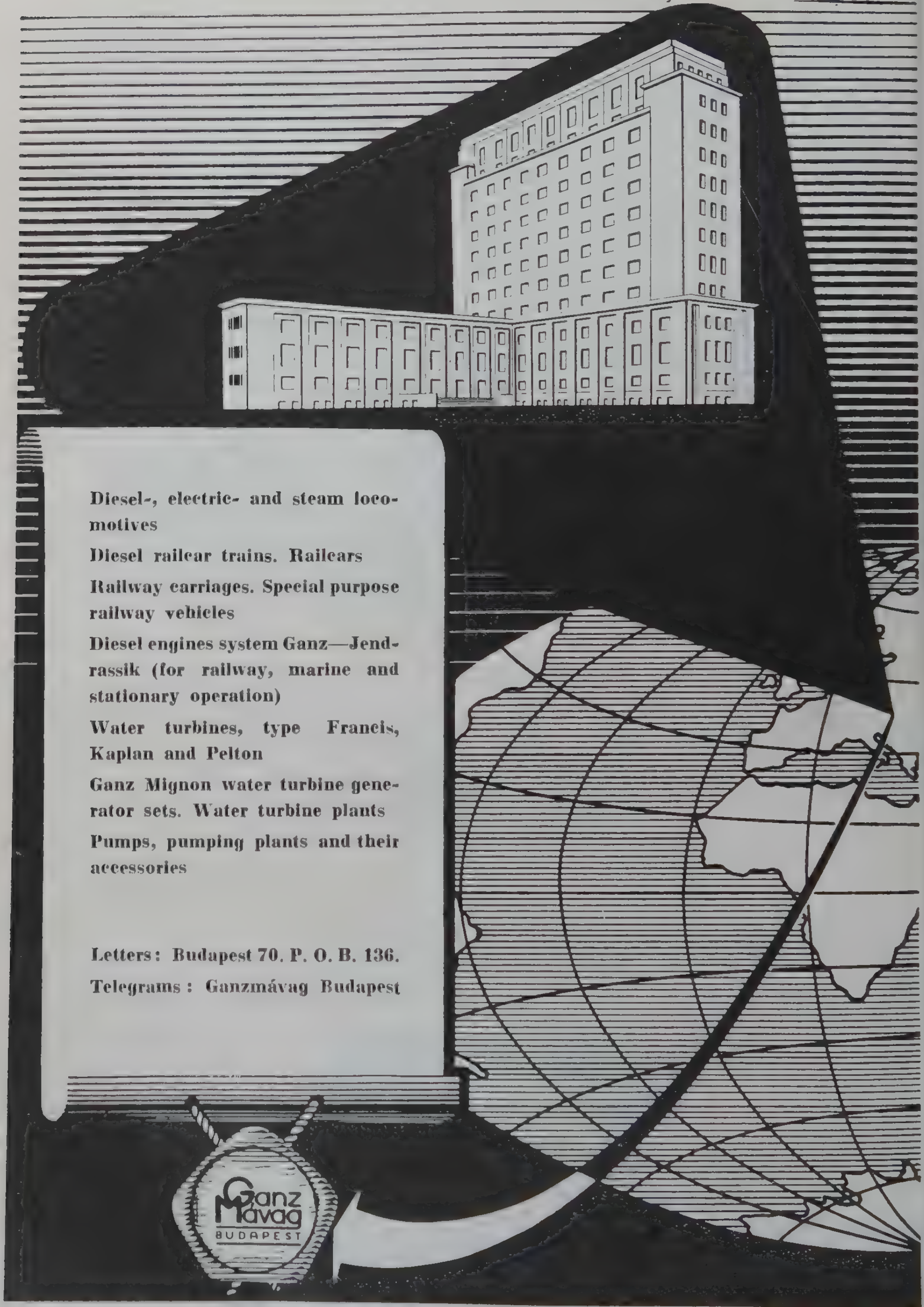

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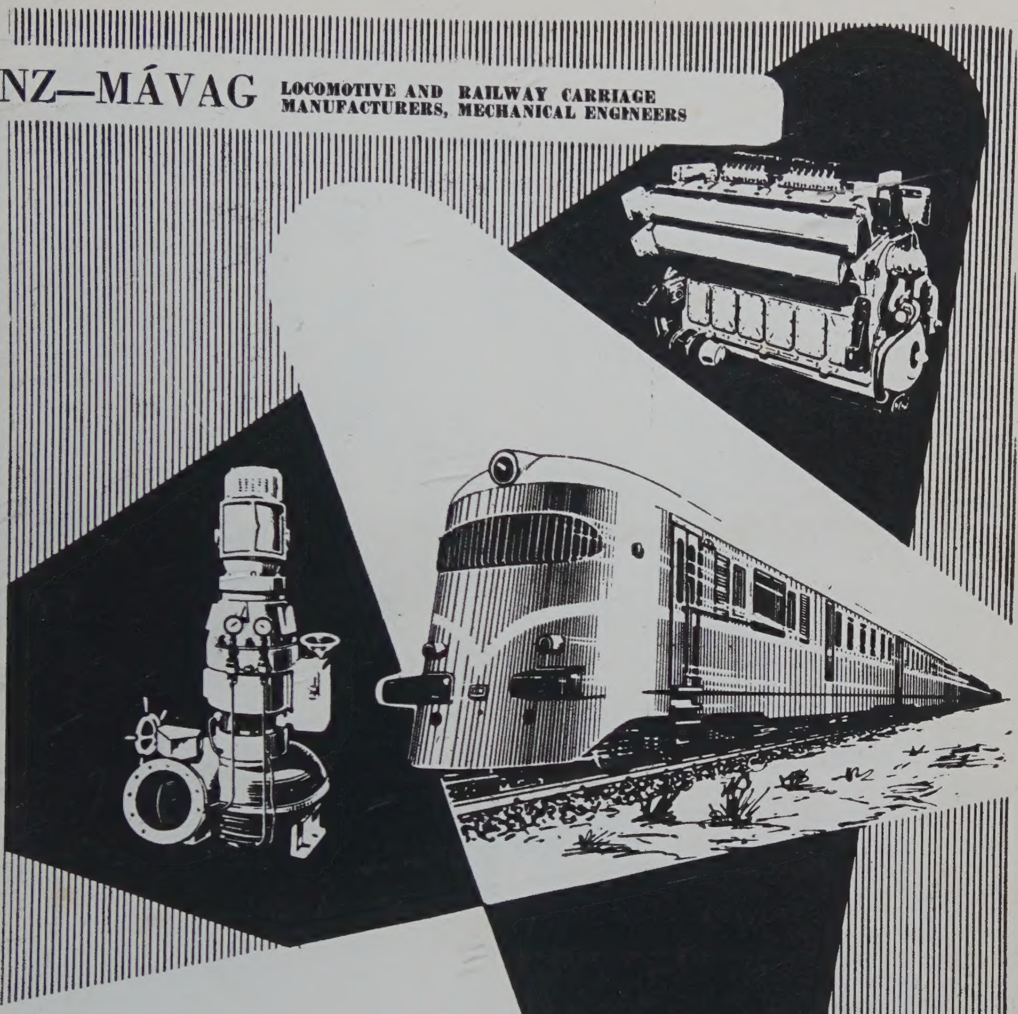

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